HIGHWOOD WATER MANAGEMENT PLAN, PHASE 1

Public Advisory Committee Final Report, June 2006

Volume 2

COMPENDIUM
OF
BACKGROUND INFORMATION

Highwood Water Management Plan, Phase 1
Public Advisory Committee Final Report, June 2006

Volume 2

Compendium of Background Information to Report and Recommendations for Highwood Diversion Plan

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Contents

Introduction

This compendium is a compilation of Fact Sheets, Technical Notes and report summaries that were prepared for the Phase I Public Advisory Committee during the course of studies conducted related to development of the Highwood Diversion Plan. The documents were prepared between 2003 and 2005. They were written in stand-alone format to summarize information about various study databases or methodologies, or to address various issues that arose during the course of the study. They reflect conditions and thinking of the study personnel at the time that they were prepared. They may not always reflect conditions and thinking of study staff and the Phase I Public Advisory Committee that evolved by the time the final report was prepared.

Most of the documents are in Fact Sheet format, which have four common headings:

- Topic
- Issues
- Discussion
- Key Messages

Names of government departments have changed over the course of the work on this project. For instance, Alberta Environmental Protection has become Alberta Environment. No effort has been made to change the names of government departments to the most recent name. Documents are written primarily using metric units. Exceptions are where it is deemed the imperial units are much more familiar and meaningful to the intended readership.

References are provided at the end of each Fact Sheet.

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: *Water Act* Licences

Issues:
- What is the extent of water allocations under the *Water Act* in the sub-basins of the study area, and for what purposes?
- What is the breakdown between groundwater and surface water licences, and mainstem and tributary licences?

Discussion:

- **Introduction**

Alberta is fortunate to have an orderly process for allocating water rights that dates back to 1894 when the Dominion Government passed the *North-West Irrigation Act*. The *Act* suppressed common law riparian rights and declared that water was the property of the Crown. Compliance with provisions of the *Act* and government approval was required to obtain the right to use water. The Dominion Government set up a complex arrangement of rules and procedures for the administration of water rights under the *Act*. The responsibility for water management was transferred to the Province in 1931. The provincial *Water Resources Act* became the principle legislation for managing water in that year. In 1999, the *Water Act* replaced the *Water Resources Act*. The legislation and administrative procedures were modified from time-to-time through the years, but many of the basic principles of the original *Act* are still evident in to-day's *Water Act*.

The legislation did not completely extinguish riparian rights. Riparian landowners have been allowed to use water for "domestic purposes" without a licence. The *Water Act* confirms that a limited amount of surface water or groundwater (1.25 dam^3/year) can be used without a licence by riparian landowners, or landowners that have a groundwater source, for "household" purposes (human consumption, sanitation, fire prevention and watering animals, gardens, lawns and trees). Earlier legislation did not quantify the riparian rights of domestic users. To protect such uses that existed at the time the *Water Act* came into force, landowners had the option to "register" up to 6.25 dam^3/year for traditional agricultural purposes (stockwatering, crop spraying) within three years (by January 1, 2002). Registration would protect the right by assigning to it a priority dating back to when the water was first put to use.

Water licences define the water allocation, and the location and purpose of projects in the study area. The allocation provides an indication of the size of the project. The allocation can be considered an upper limit of water use. The entire allocation may not be used every year, depending on many factors, such as weather conditions, priority, licence conditions, water availability, and economic circumstances. Also, because of the continuing existence of riparian rights, not all water uses are reflected in the water licence database. The "household uses" that are not included in the database are a small percentage of the licensed use.

- **The Licences**

A listing of water licences in the Highwood, Sheep, Little Bow and Mosquito Creek Basins was provided by AENV in February 2002. Water licences were sorted by sub-basin, purpose, mainstem and tributaries. Surface water and groundwater licences were summarized separately. Registered wells are included as

stockwater projects. Surface water projects registered for traditional agricultural uses were not available at the time the listing of projects was prepared. The total allocations for the registered surface water projects are expected to be small in relation to other surface water projects. (In any event, cattle populations have been used to estimate stockwater demand, rather than licences.)

Summaries of all licences with the foregoing breakdown are attached as Tables 1 to 9. Observations from review of the tables and individual licences are as follows:

- Highwood River upstream of Women's Coulee Diversion
  - The largest irrigation licence is on Pekisko Creek. It has a 1907 priority.
  - Municipal licences include the Eden Valley Indian Reserve (surface water) and the Village of Longview (groundwater, adjacent to the river).
  - Two industrial licences for enhanced oil recovery represent the largest allocation in the sub-basin.
  - The largest stockwater allocation is 12 dam^3/year.

- Highwood River -- Women's Coulee Diversion to downstream of Little Bow Diversion
  - Stockwatering includes a mainstem licence to a feedlot. Largest tributary stockwater allocation is 16 dam^3/year.
  - Municipal includes 13 wells licensed to High River and one to the M. D. of Foothills. All are within one section of land traversed by the Highwood River. Total pumping rate from 12 production wells is 0.358 m^3/s. For modeling purposes, withdrawals from these wells are assumed to be equivalent to a direct withdrawal from the Highwood River. The treated effluent (return flow) from the High River wells is being pumped to Frank Lake.
  - Two industrial licences are for wells in the same section of land as the High River wells. For consistency, withdrawals from these wells should be considered direct withdrawals from the Highwood River.
  - The two stabilization licences are for Women's Coulee Diversion. One licence for diversion of 0.71 m^3/s has a 1933 priority; the second licence for diversion of 0.99 m^3/s has a 1979 priority.
  - A licence for the Little Bow Diversion was not included in the listing. The licensing situation for the Little Bow diversion has a complex history dating back to 1905 and involving the Territorial Government, the Little Bow Irrigation District and the Province. Upon demise of the Little Bow Irrigation District in 1950, the works were taken over by the Province. At that time, the Crown was not bound by the Water *Resources Act* (prior to 1971), and was deemed not to require a licence to operate works (Alberta Environment. 1997). The works are currently operated by Alberta Environment to serve the purposes for which the 1905 and 1922 applications were made (irrigation and domestic uses). In response to a 1997 application, an interim licence was granted under the *Water Resources Act* authorizing an enlargement of the diversion capacity from the current of 2.8 m^3/s to 8.5 m^3/s.
  - Two irrigation licences are for golf course irrigation. Total allocation: 142 dam^3.

- Highwood River -- Downstream of Little Bow Diversion to Aldersyde
  - One mainstem irrigation licence is for a sod farm.
  - All tributary licences (35) are allocations from Tongue Creek.
  - The largest surface water stockwatering allocation is 86 dam^3/year (feedlot).
  - The wetlands project is to divert Highwood River water to Frank Lake when required to supplement the treated effluent diversions.

- Highwood River – Aldersyde to Sheep River Confluence
  - This reach has licences for a rural subdivision and a golf course. The golf course has not been developed. The subdivision is being served by pipeline from the Town of High River Water Treatment Plant.

- Highwood River – Sheep River Confluence to Mouth
  - This reach has only two mainstem licences (irrigation) and 3 tributary licences (stockwater).

- Sheep River Sub-basin
  - Stockwatering includes one mainstem licence with an allocation of 291 dam^3/year.
  - Three mainstem irrigation licences are for golf course irrigation.
  - Municipal allocations include 24 groundwater licences for the Towns of Okotoks (12), Turner Valley (9), and Black Diamond (3). The wells are near the Sheep River. For modeling purposes, these withdrawals have been considered equivalent to direct withdrawals from the river.
  - Three surface water injection projects.

- Upper Little Bow River Sub-basin
  - Irrigation licences: 19 on the mainstem; one tributary licence.
  - Municipal licences include one surface water licence to the Town of Vulcan and three deep wells for the Hamlet of Blackie. The Town of Vulcan will draw water from the Little Bow River Reservoir during normal operations. The location of their intake is such that under severe reservoir drawdown conditions, the Town may be dependent upon river flows to meet their needs. For purposes of this work, the Town's allocation is considered to be in the Upper Little Bow Sub-basin.
  - Diversions from the Little Bow Canal to Emerson and Sunshine Lakes in High River are made from time-to-time under temporary authorizations. Diversions are required to circulate water to maintain water quality (flow is returned to the canal), and to replace evaporation losses.

- Lower Little Bow River Sub-basin
  - Irrigation licences: 62 on the mainstem; three on tributaries (Long Coulee).
  - Municipal allocations are for Carmangay (surface water) and the Town of Stavely (groundwater).
  - The wetlands project is on a tributary west of Champion.

- Mosquito Creek Sub-basin
  - Irrigation licences include 25 on mainstem Mosquito Creek, four on Women's Coulee and four on tributaries.
  - Of 94 surface stockwater projects, the largest single allocation is for 18.5 dam^3/year. Some of the stockwater projects are on mainstem Mosquito Creek upstream of the Women's Coulee confluence. As such, these projects do not have access to Highwood River water.
  - The two golf course licences are for the Town of Nanton.
  - Municipal licences are for the Town of Nanton (one surface and one groundwater), and for the Hamlet of Cayley (Women's Coulee).
  - Water has been diverted to Clear Lake under an interim licence issued in January 2000.

Summary

The licences for the sub-basins are summarized in Table 10.

- The Little Bow Basin has more than double the number of licences than either the Highwood River Basin or the Sheep River Basin. Almost half of the licences in the Little Bow Basin are for irrigation.

- The predominant allocation in the Highwood River Basin is for irrigation (38%), followed by recreation (22%), and then industry (14%).

- The predominant allocation in the Sheep River Basin is for industry (30%), followed by irrigation (23%), and municipal (22%).

- Irrigation is by far the highest water allocation in the Upper and Lower Little Bow River Sub-basins, being close to 90% of the total allocation in each sub-basin.

- Irrigation has 68% of the total allocation in the Mosquito Creek Basin. Municipal has the next highest allocation (15%).

Reference

Alberta Environment. 1997. Little Bow Diversion summary document submitted to the Joint Review Panel, Highwood/Little Bow EIA Public Hearings. AENV. Lethbridge, AB.

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Table 1. Highwood River Basin upstream of Women's Coulee -- Summary of February 2002 licences.

PURPOSE		Surface Water No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	Groundwater No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**2**	**268.0**	**268.0**	**0.0**	**0.0**	**50.3**	**0.05**					
	Tributaries	1	925.0	740.0	185.0	0.0	718.0	0.51					
	Sub-total	3	1193.0	1008.0	185.0	0.0	768.3	0.56	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	24	274.0	28.0	245.0	0.0			16	73.3	73.3	0.0	0.0
	Registration								45	34.8	34.8	0.0	0.0
	Sub-total	24	274.0	28.0	245.0	0.0	0.0	0	61	108.1	108.1	0.0	0.0
Other Agric.	Feedlot								4	52.3	52.3	0.0	0.0
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	4	52.3	52.3	0.0	0.0
Recreation	Wetlands												
	Parks												
	Golf courses												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages	**1**	**75.0**	**75.0**	**0.0**	**0.0**		**0.059**	**1**	**98.7**	**19.7**	**0.0**	**78.9**
	Schools												
	Camps												
	Subdivisions	1	1.0	1.0	0.0	0.0							
	Co-ops	**1**	**1.0**	**1.0**	**0.0**	**0.0**							
	Other (Inst.)												
	Sub-total	3	77.0	77.0	0.0	0.0	0.0	0.059	1	98.7	19.7	0.0	78.9
Industrial	Aggregate wash												
	Bottling												
	Injection	**2**	**1653.0**	**1653.0**	**0.0**	**0.0**		**0.059**					
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other												
	Sub-total	2	1653.0	1653.0	0.0	0.0	0.0	0.059	0	0.0	0.0	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		32	3197.0	2766.0	430.0	0.0	768.3	0.678	66	259.1	180.1	0.0	78.9

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 2. Highwood River Basin: Women's Coulee to Little Bow diversion -- Summary of February 2002 licences.

PURPOSE		Surface Water No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³	AREA ha	RATE m³/s	Groundwater No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³
Irrigation	Mainstem	**7**	**1055.0**	**1039.0**	**16.0**	**0.0**	**416.4**	**0.806**					
	Tributaries												
	Sub-total	7	1055.0	1039.0	16.0	0.0	416.4	0.806	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	**1**	**518.0**	**518.0**	**0.0**	**0.0**		**0.025**					
	Tributaries	3	26.0	4.0	22.0	0.0							
	Registration								9	4.7	4.7	0.0	0.0
	Sub-total	4	544.0	522.0	22.0	0.0	0.0	0.025	9	4.7	4.7	0.0	0.0
Other Agric.	Feedlot												
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	Wetlands												
	Parks												
	Golf courses												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages								**14**	**4741.5**	**1044.0**	**0.0**	**3697.5**
	Schools												
	Camps												
	Subdivisions												
	Co-ops												
	Other (Inst.)												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	14	4741.5	1044.0	0.0	3697.5
Industrial	Aggregate wash												
	Bottling												
	Injection												
	Gas /Petro								**1**	**69.1**	**69.1**	**0.0**	**0.0**
	Ind'l processing												
	Construction												
	Other								**1**	**1180.4**	**0.0**	**59.0**	**1121.4**
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	2	1249.5	69.1	59.0	1121.4
Water Mgmt	Remediation												
	Stabilization	2	27146.0	27146.0	0.0	0.0		1.7					
	Sub-total	2	27146.0	27146.0	0.0	0.0	0.0	1.7	0	0.0	0.0	0.0	0.0
SUB-BASIN	TOTAL	13	28745.0	28707.0	38.0	0.0	416.4	2.531	25	5995.7	1117.8	59.0	4818.9

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.
8. The groundwater licences in bold type are from wells near the Highwood River. In former planning programs, these withdrawals have been considered equivalent to surface water withdrawals.

Table 3. Highwood River Basin: Little Bow diversion to Aldersyde -- Summary of February 2002 licences.

PURPOSE		Surface Water No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³	AREA ha	RATE m³/s	Groundwater No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³
Irrigation	Mainstem	**8**	**930.0**	**930.0**	**0.0**	**0.0**	**458.3**	**0.322**					
	Tributaries	2	63.0	63.0	0.0	0.0	106.1	0.038					
	Sub-total	10	993.0	993.0	0.0	0.0	564.4	0.36	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	33	225.0	68.0	158.0	0.0		0.056	32	200.0	200.0	0.0	0.0
	Registration								58	35.1	35.1	0.0	0.0
	Sub-total	33	225.0	68.0	158.0	0.0	0.0	0.056	90	235.1	235.1	0.0	0.0
Other Agric.	Feedlot								1	59.7	59.7	0.0	0.0
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	1	59.7	59.7	0.0	0.0
Recreation	Wetlands	**1**	**2467.0**	**0.0**	**0.0**	**2467.0**							
	Parks												
	Golf courses												
	Other												
	Sub-total	1	2467.0	0.0	0.0	2467.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages												
	Schools												
	Camps												
	Subdivisions												
	Co-ops												
	Other (Inst.)												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Industrial	Aggregate wash												
	Bottling												
	Injection												
	Gas /Petro								1	2.5	2.5	0.0	0.0
	Ind'l processing												
	Construction												
	Other								2	194.0	182.1	0.0	11.8
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	3	196.5	184.6	0.0	11.8
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		44	3685.0	1061.0	158.0	2467.0	564.4	0.416	94	491.3	479.4	0.0	11.8

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 4. Highwood River Basin: Aldersyde to Sheep River confluence -- Summary of February 2002 licences.

Sheep River Basin not included.

PURPOSE		Surface Water							Groundwater				
		No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**12**	**1097.0**	**1097.0**	**0.0**	**0.0**	**360.0**	**0.380**					
	Tributaries												
	Sub-total	12	1097.0	1097.0	0.0	0.0	360.0	0.38	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	3	7.0	2.0	5.0	0.0							
	Registration								8	5.5	5.5	0.0	0.0
	Sub-total	3	7.0	2.0	5.0	0.0	0.0	0	8	5.5	5.5	0.0	0.0
Other Agric.	Feedlot												
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	Wetlands												
	Parks												
	Golf courses	**1**	**62.0**	**62.0**	**0.0**	**0.0**							
	Other												
	Sub-total	1	62.0	62.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages												
	Schools												
	Camps												
	Subdivisions	**1**	**86.0**	**86.0**	**0.0**	**0.0**							
	Co-ops	**1**	**1.0**	**1.0**	**0.0**	**0.0**		**0.001**					
	Other (Inst.)												
	Sub-total	2	87.0	87.0	0.0	0.0	0.0	0.001	0	0.0	0.0	0.0	0.0
Industrial	Aggregate wash												
	Bottling												
	Injection												
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		18	1253.0	1248.0	5.0	0.0	360.0	0.381	8	5.5	5.5	0.0	0.0

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 5. Highwood River Basin: Sheep River confluence to the mouth -- Summary of February 2002 licences.

Sheep River Basin not included.

PURPOSE		Surface Water							Groundwater				
		No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**2**	**82.0**	**82.0**	**0.0**	**0.0**	**49.4**	**0.014**					
	Tributaries												
	Sub-total	2	82.0	82.0	0.0	0.0	49.4	0.014	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	3	25.0	19.0	6.0	0.0		0.002	1	2.5	2.5	0.0	0.0
	Registration								10	4.0	4.0	0.0	0.0
	Sub-total	3	25.0	19.0	6.0	0.0	0.0	0.002	11	6.5	6.5	0.0	0.0
Other Agric.	Feedlot												
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	Wetlands												
	Parks												
	Golf courses												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages												
	Schools												
	Camps												
	Subdivisions								1	7.4	7.4	0.0	0.0
	Co-ops												
	Other (Inst.)												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	1	7.4	7.4	0.0	0.0
Industrial	Aggregate wash												
	Bottling												
	Injection												
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		5	107.0	101.0	6.0	0.0	49.4	0.016	12	13.9	13.9	0.0	0.0

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 6. Sheep River Basin -- Summary of February 2002 licences.

PURPOSE		Surface Water No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	Groundwater No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**15**	**1232.0**	**1226.0**	**6.0**	**0.0**	**558.2**	**1.139**					
	Tributaries												
	Sub-total	15	1232.0	1226.0	6.0	0.0	558.2	1.139	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	90	890.0	401.0	490.0	0.0		0.012	41	113.6	113.6	0.0	0.0
	Registration								184	119.2	119.2	0.0	0.0
	Sub-total	90	890.0	401.0	490.0	0.0	0.0	0.012	225	232.8	232.8	0.0	0.0
Other Agric.	Feedlot												
	Fish	**1**	**1.0**	**0.0**	**1.0**	**0.0**							
	Gardens	**1**	**123.0**	**123.0**	**0.0**	**0.0**	**60.7**	**0.023**	2	5.2	5.2	0.0	0.0
	Sub-total	2	124.0	123.0	1.0	0.0	60.7	0.023	2	5.2	5.2	0.0	0.0
Recreation	Wetlands												
	Parks	**1**	**99**	**95**	**4**	**0**	**21.1**	**0.028**					
	Golf courses	**2**	**211.0**	**211.0**	**0.0**	**0.0**	**76.9**	**0.065**					
	Other	**1**	**43.0**	**12.0**	**31.0**	**0.0**			9	36.9	36.9	0.0	0.0
	Sub-total	4	353.0	318.0	35.0	0.0	98.0	0.093	9	36.9	36.9	0.0	0.0
Municipal	Towns, Villages								**24**	**3690.5**	**1209.7**	**0**	**2480.8**
	Schools								3	6.2	6.2	0.0	0.0
	Camps								1	1.2	1.2	0.0	0.0
	Subdivisions								4	15.0	15.0	0.0	0.0
	Co-ops	**3**	**54.0**	**49.0**	**5.0**	**0.0**		**0.035**					
	Other (Inst.)												
	Sub-total	3	54.0	49.0	5.0	0.0	0.0	0.035	32	3712.9	1232.1	0.0	2480.8
Industrial	Aggregate wash	**1**	**62.0**	**49.0**	**12.0**	**0.0**		**0.025**					
	Bottling												
	Injection	**2**	**715.0**	**715.0**	**0.0**	**0.0**		**0.028**					
	Tributary	1	740.0	740.0	0.0	0.0							
	Gas /Petro								2	49.3	49.3	0.0	0.0
	Ind'l processing												
	Construction												
	Other												
	Tributary	1	74.0	74.0	0.0	0.0			2	6.6	6.6	0.0	0.0
	Sub-total	5	1591.0	1578.0	12.0	0.0	0.0	0.053	4	55.9	55.9	0.0	0.0
Water Mgmt	Remediation								4	69.1	69.1	0.0	0.0
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	4	69.1	69.1	0.0	0.0
SUB-BASIN TOTAL		119	4244.0	3695.0	549.0	0.0	716.9	1.355	276	4112.8	1632.0	0.0	2480.8

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.
8. The groundwater licences in **bold type** are from wells near the Sheep River. In former planning programs, these withdrawals have been considered equivalent to surface water withdrawals.

Table 7. Upper Little Bow Basin -- Summary of February 2002 licences.

UPPER LITTLE BOW RIVER BASIN (Upstream of the Little Bow River Reservoir)

		Surface Water							Groundwater				
PURPOSE		No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³	AREA ha	RATE m³/s	No. Lic.	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³
Irrigation	Mainstem	**19**	**2145.0**	**2145.0**	**0.0**	**0.0**	**687.3**	**0.915**					
	Tributaries	1	18.5	18.5	0.0	0.0	4.0	0.019					
	Sub-total	20	2163.5	2163.5	0.0	0.0	691.3	0.934	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	7	39.4	16.0	23.4	0.0	0.0	0.003	29	200.3	200.3	0.0	0.0
	Registration								145	113.4	113.4	0.0	0.0
	Sub-total	7	39.4	16.0	23.4	0.0	0.0	0.003	174	313.7	313.7	0.0	0.0
Other Agric.	Feedlot												
	Fish												
	Gardens								2	4.9	4.9	0.0	0.0
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	2	4.9	4.9	0.0	0.0
Recreation	Wetlands												
	Parks												
	Golf courses												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	Towns, Villages	**1**	**296.0**	**296.0**	**0.0**	**0.0**	**0.0**	**0.071**	3	70.3	14.1	0.0	56.2
	Schools												
	Camps												
	Subdivisions												
	Co-ops	**1**	**17.0**	**12.0**	**5.0**	**0.0**		**0.045**	5	24.7	24.7	0.0	0.0
	Other (Inst.)												
	Sub-total	2	313.0	308.0	5.0	0.0	0.0	0.116	8	95.0	38.7	0.0	56.2
Industrial	Aggregate wash												
	Bottling								1	35.8	35.8	0.0	0.0
	Injection												
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other								1	1.2	1.2	0.0	0.0
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	2	37.0	37.0	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		29	2516.0	2487.5	28.4	0.0	691.3	1.053	186	450.6	394.3	0.0	56.2

Notes:

1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 8. Lower Little Bow Basin -- Summary of February 2002 Licences

LOWER LITTLE BOW RIVER BASIN (From the Little Bow River Reservoir to upstream of Travers Reservoir)

PURPOSE		Surface Water							Groundwater				
		No. . Lic	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**62**	**15285**	**15272**	**12**	**0**	**3673.8**	**3.617**	1	61.7	61.7	0	0
	Tributaries	3	112.3	93	7.4	12	42.9	0.021					
	Sub-total	65	15397.3	15365.0	19.4	12.0	3716.7	3.638	1	61.7	61.7	0.0	0.0
Agric/Stock	Stockwatering	22	128.0	28.0	100.0	0		0	10	86.3	86.3	0	0
	Registration								169	126.1	126.1	0	0
	Sub-total	22	128.0	28.0	100.0	0.0	0.0	0	179	212.4	212.4	0.0	0.0
Other Agric.	Feedlot												
	Fish	1	21	0	21	0	0	0					
	Gardens												
	Sub-total	1	21.0	0.0	21.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	Wetlands	1	509	0	509	0		0					
	Parks												
	Golf courses												
	Other								1	1.2	1.2	0	0
	Sub-total	1	509.0	0.0	509.0	0.0	0.0	0	1	1.2	1.2	0.0	0.0
Municipal	Towns, Villages	**1**	**93**	**19**	**74**	**0.0**		**0.007**	1	92.5	18.5	0.0	74.0
	Schools												
	Camps												
	Subdivisions												
	Co-ops	**5**	**270**	**208**	**62**	**0.0**		**0.069**	10	136.3	136.3	0.0	0.0
	Other (Inst.)												
	Sub-total	6	363.0	227.0	136.0	0.0	0.0	0.076	11	228.8	154.8	0.0	74.0
Industrial	Aggregate wash												
	Bottling								1	76.5	76.5	0.0	0.0
	Injection												
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	1	76.5	76.5	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		95	16418.3	15620.0	785.4	12.0	3716.7	3.714	193	580.6	506.6	0.0	74.0

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**.

Table 9. Mosquito Creek Basin -- Summary of February 2002 licences.

MOSQUITO CREEK BASIN (Including Women's Coulee)

		Surface Water							Groundwater				
PURPOSE		No. Lic.	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3	AREA ha	RATE m^3/s	No. . Lic	ALLOC dam^3	CONS dam^3	LOSS dam^3	RETURN dam^3
Irrigation	Mainstem	**25**	**2513.0**	**2510.0**	**0.0**	**2.0**	**686.2**	**0.806**					
	W. Coulee	**4**	**418.0**	**418.0**	**0.0**	**0.0**	**159.5**	**0.189**					
	Tributaries	4	268.0	258.0	10.0	0.0	111.8	0.210					
	Sub-total	33	3199.0	3186.0	10.0	2.0	957.5	1.205	0	0.0	0.0	0.0	0.0
Agric/Stock	Stockwatering	94	481.0	130.0	351.0	0.0			65	362.9	362.9	0	0
	Registration								156	134.3	134.3	0	0
	Sub-total	94	481.0	130.0	351.0	0.0	0.0	0.000	221	497.2	497.2	0.0	0.0
Other Agric.	Feedlot								2	9.7	9.7	0	0
	Fish												
	Gardens												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0.000	2	9.7	9.7	0.0	0.0
Recreation	Wetlands												
	Parks								1	1.2	1.2	0	0
	Golf courses	**2**	**136.0**	**136.0**	**0.0**	**0.0**	**29.6**	**0.760**					
	Other												
	Sub-total	2	136.0	136.0	0.0	0.0	29.6	0.760	1	1.2	1.2	0.0	0.0
Municipal	Towns, Villages	**1**	**616.7**	**104.9**	**18.5**	**493.4**		**0.099**	1	18.5	3.7	0.0	14.8
	W. Coulee	**1**	**86.4**	**17.3**	**2.5**	**66.6**		**0.009**					
	Schools												
	Camps												
	Subdivisions												
	Co-ops								7	23.5	23.5	0.0	0.0
	Other (Inst.)												
	Sub-total	2	703.1	122.1	21.0	560.0	0.0	0.108	8	42.0	27.2	0.0	14.8
Industrial	Aggregate wash	**1**	**173.0**	**17.0**	**0.0**	**155.0**		**0.076**					
	Bottling								1	8.6	8.6	0.0	0.0
	Injection												
	Gas /Petro												
	Ind'l processing												
	Construction												
	Other	2	14.0	11.0	2.0	0.0			2	1.2	1.2	0	0
	Sub-total	3	187.0	28.0	2.0	155.0	0.0	0.076	3	9.8	9.8	0.0	0.0
Water Mgmt	Remediation												
	Stabilization												
	Sub-total	0	0.0	0.0	0.0	0.0	0.0	0.000	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL		134	4706.1	3602.1	384.0	717.0	987.1	2.149	235	559.9	545.1	0.0	14.8

Notes:
1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. **Mainstem licences in bold type**. Exception: Some stockwater projects are on mainstem Mosquito Creek upstream of Women's Coulee.

Table 10. Summary of February 2002 licences within sub-basins in the study area.

PURPOSE	Surface Water							Groundwater				
	No. Lic	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³	AREA ha	RATE m³/s	No.. Lic	ALLOC dam³	CONS dam³	LOSS dam³	RETURN dam³
Highwood River Basin (excluding the Sheep River Sub-basin)												
Irrigation	34	4420.0	4219.0	201.0	0.0	2158.5	2.120	0	0.0	0.0	0.0	0.0
Agric/Stock	67	1075.0	639.0	436.0	0.0		0.083	179	359.9	359.9	0.0	0.0
Other Agric.	0	0.0	0.0	6.0	0.0			5	112.0	112.0	0.0	0.0
Recreation	2	2529.0	62.0	0.0	2467.0			0	0.0	0.0	0.0	0.0
Municipal	5	164.0	164.0	0.0	0.0		0.060	16	4847.6	1071.1	0.0	3776.4
Industrial	2	1653.0	1653.0	0.0	0.0		0.059	5	1446.0	253.7	59.0	1133.2
Water Mgmt.*	*2*	*27146*	*27146*	*0.0*	*0.0*		*1.700*	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL*	110	9841.0	6737.0	643.0	2467.0	2158.5	2.322	205	6765.5	1796.7	59	4909.6
Sheep River Sub-basin												
Irrigation	15	1232.0	1226.0	6	0.0	558.2	1.139	0	0.0	0.0	0.0	0.0
Agric/Stock	90	890.0	401.0	490.0	0.0		0.012	225	232.8	232.8	0.0	0.0
Other Agric.	2	124.0	123.0	1.0	0.0	60.7	0.023	2	5.2	5.2	0.0	0.0
Recreation	4	353.0	318.0	35.0	0.0	98.0	0.093	9	36.9	36.9	0.0	0.0
Municipal	3	54.0	49.0	5.0	0.0	0.0	0.035	32	3712.9	1232.1	0.0	2480.8
Industrial	5	1591.0	1578.0	12.0	0.0	0.0	0.053	4	55.9	55.9	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0			4	69.1	69.1	0.0	0.0
SUB-BASIN TOTAL	119	4244.0	3695.0	549.0	0.0	716.9	1.355	276	4112.8	1632.0	0	2480.8
Upper Little Bow River Sub-basin												
Irrigation	20	2163.5	2163.5	0.0	0.0	691.3	0.934	0	0.0	0.0	0.0	0.0
Agric/Stock	7	39.43	16.0	23.42	0.0	0.0	0.003	174	313.7	313.7	0.0	0.0
Other Agric.	0	0.0	0.0	0.0	0.0	0.0	0	2	4.9	4.9	0.0	0.0
Recreation	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Municipal	2	313.0	308.0	5.0	0.0	0.0	0.116	8	95.0	38.7	0.0	56.2
Industrial	0	0.0	0.0	0.0	0.0	0.0	0	2	37.0	37.0	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	29	2516.0	2487.5	28.4	0.0	691.3	1.053	186	450.6	394.3	0.0	56.2
Lower Little Bow River Sub-basin												
Irrigation	65	15397.3	15365.0	19.4	12.0	3716.7	3.638	1	61.7	61.7	0.0	0.0
Agric/Stock	22	128.0	28.0	100.0	0.0	0.0	0	179	212.4	212.4	0.0	0.0
Other Agric.	1	21.0	0.0	21.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Recreation	1	509.0	0.0	509.0	0.0	0.0	0	1	1.2	1.2	0.0	0.0
Municipal	6	363.0	227.0	136.0	0.0	0	0.076	11	228.8	154.8	0.0	74.0
Industrial	0	0.0	0.0	0.0	0.0	0.0	0.0	1	76.5	76.5	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	95	16418.3	15620	785.4	12.0	3716.7	3.714	193	580.6	506.6	0.0	74.0
Mosquito Creek Sub-basin (including Women's Coulee)												
Irrigation	33	3199.0	3186.0	10.0	2.0	957.5	1.205	0	0.0	0.0	0.0	0.0
Agric/Stock	94	481.0	130.0	351.0	0.0	0.0	0	221	497.2	497.2	0.0	0.0
Other Agric.	0	0.0	0.0	0.0	0.0	0.0	0	2	9.7	9.7	0.0	0.0
Recreation	2	136.0	136.0	0.0	0.0	29.6	0.76	1	1.2	1.2	0.0	0.0
Municipal	2	703.1	122.1	21.0	560.0	0.0	0.108	8	42.0	27.2	0.0	14.8
Industrial	3	187.0	28.0	2.0	155.0	0.0	0.076	3	9.8	9.8	0.0	0.0
Water Mgmt.	0	0.0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SUB-BASIN TOTAL	134	4706.09	3602.12	383.97	717.0	987.1	2.149	235	559.9	545.1	0.0	14.8

Notes:

* The Highwood River Sub-basin total excludes the 2 water management licences (diversions to Women's Coulee Reservoir) to provide a better comparison of development within each sub-basin.

1. ALLOC refers to allocation or withdrawal.
2. CONS indicates expected consumption.
3. LOSS indicates expected losses due to evaporation, infiltration, etc.
4. RETURN indicates expected return flow.
5. AREA refers to the size of irrigation projects.
6. RATE refers to maximum diversion rate.
7. Data includes mainstem and tributary licences.

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Municipal and Rural Domestic Water Use

Issues:
- What are the primary sources of municipal and rural domestic water uses?
- What is the extent of municipal and rural domestic water withdrawals and consumptive use in the study area?
- How much treated wastewater is returned to the source streams?

Discussion:

- **Introduction**

In this document, use of water for municipal purposes refers to withdrawing water from a surface or groundwater source, treating the water to comply with Health Canada's Guidelines for Drinking Water Quality, distributing it to homes, commercial and institutional establishments, and industrial users within an urban area. Municipal water use often involves irrigation of parks and golf courses, and uses related to other recreational and aesthetic amenities within the urban areas. Water use records indicate that municipal use is usually highest in the summer months, primarily due to outside watering of lawns, gardens and parks. Not all water withdrawn from the source is consumed. The portion not consumed is usually treated to remove impurities and released to the source stream or other receiving body as wastewater effluent, commonly referred to as return flow. Return flow is a mixed blessing – it can be used to supply downstream water demands, but it sometimes contributes to water quality problems in the receiving stream.

Population is a key factor in determining municipal water requirements. However, per capita consumptive use computed from records of withdrawals and return flows for urban centres often vary because of factors such as infrastructure design, unrecorded amounts of water provided for domestic and other uses outside the urban center, unrecorded amounts of treated effluent used for irrigation or wildlife projects, and groundwater seepage into sewerage systems (Hydroconsult. 2001).

In this document, rural domestic use refers to household, lawn and garden uses for individual dwellings that are not served by a distribution system. Groundwater aquifers are the primary sources for rural domestic water users. Wastewater is usually returned to the environment through septic fields constructed in compliance with standards. There are records of wells in the study area, but metered records of rural domestic uses and wastewater discharges are not normally kept.

- **Population**

The population of urban centers in the study area was obtained from 2001 StatsCan census data (Table 1). Data for 1996 provides an indication of growth rates for the urban centers between 1996 and 2001. The water supply sources and the recipient water bodies for return flow are also listed in Table 1. The Town of High River is located in both the Highwood and Little Bow River basins. Since the Highwood River is its source of water supply (via groundwater), High River's entire population is assumed to be in the Highwood River basin. The Town of Vulcan is located just outside the Little Bow River Basin. Its population is included in the Upper Little Bow Sub-basin since the Little Bow River is its water supply source.

The populations of the rural portions of the study area were based upon the populations of rural municipalities that are within the various sub-basins. Pro-rating factors that apply to each sub-basin were taken from the study carried out by Hydroconsult (1999).

- **Town of High River Water Use**

The Town of High River's water use was analyzed separately from other urban centers in the study area. There are several factors that make the town's water use unique in the study area.

- The Town is a large urban population centre upstream of the critical fishery habitat reach of the Highwood River.
- The source of the Town's water is 10 shallow production wells near the Highwood River, at least three of which are fed directly from the river. There is uncertainty regarding the recharge area for the other seven wells.
- The Town supplies water to Cargill Foods and the Mazeppa gas plant, both of which are outside the town. Cargill Foods is the largest industrial water user in the study area.
- The Town supplies water to the M.D. of Foothills to distribute to near-by rural residents and industries (Saddle Brook Industrial Park, large truck wash, Silver Tip Subdivision, Maple Leaf Water Co-op).
- Treated wastewater from the Town and Cargill Foods is returned to Frank Lake within the Little Bow River Basin, rather than to the Highwood River.
- A portion of the town's wastewater has been used for effluent irrigation, and not returned to the Highwood River or Frank Lake.

From the Town of High River's water use (withdrawal) records over the past three years, the average annual per capita withdrawal for domestic, commercial and institutional purposes (the Town's water use) was 0.828 m^3/capita-day (table below). Based upon the average per capita use

Water uses supplied by the Town of High River.

	1999	**2000**	**2001**	**Mean**	**Return Flow**
Population	8490 est.	8900 est.	9345		
Town of High River (dam^3)	2463.8	2630.7	3003.4		55%
(m^3/capita-day)	0.795	0.810	0.880	0.828	
Cargill Foods (dam^3)		2008.3	2060.9		95%
Mazeppa Gas Plant (dam^3)		29.2	34.3		0%
M.D. of Foothills (dam^3)		69.1	67.6		10%*

* The M.D. of Foothills returns about 10% of its withdrawal to High River for treatment. Additional wastewater is discharged to private on-site septic fields.

for the three-year period and 2001 population, the current level of withdrawal is estimated to be 2824.2 dam^3 (Table 2).

Based upon 1999 data, the per capita withdrawal for the Town of High River (excluding Cargill, Mazeppa and M.D. of Foothills) is considerably higher than other large urban centers in the study area (Table 2). The reason for this is not readily apparent. It is noteworthy that the town is embarking on an ambitious water conservation program that will address possible loss of water from their distribution system, and include changes in the rate structure, water conservation education and rationing during critical periods.

The Town of High River supplies treated water to Cargill Foods, the Mazeppa Gas Plant and the M.D. of Foothills under water supply agreements. Each of these users has their own licensed water allocation under the *Water Act*, and has developed their own raw water sources of supply. Like the town, these users are supplied from wells near the Highwood River.

Based upon the Town of High River's records, the town returns about 55% of its withdrawal to Frank Lake as treated wastewater, Cargill returns about 95% of its withdrawal, also to Frank Lake, the Mazeppa Gas Plant has no return flow, and the M.D. of Foothills returns about 10% of its withdrawal to the High River wastewater system for treatment (table above). The Silver Tip Subdivision, and other rural residents supplied by the M.D. of Foothills' waterline (total of about 220 residents), discharge wastewater to on-site septic fields.

- **Other Municipal Users**

Water withdrawals for four other communities in the study area (Black Diamond, Turner Valley, Nanton and Vulcan) were obtained from the 1999 Canadian Municipal Water Use Database Survey (Environment Canada 1999). The data included all domestic, commercial, institutional and industrial uses within the communities (Table 2). The 1999 per capita withdrawals were used to estimate the 2001 withdrawals by adjusting for the population change. Water use information for 2001 was obtained from the Town of Okotoks. The per capita water use for the five communities was reasonably consistent, averaging 0.493 m^3/capita-day. This average value was used to estimate 2001 withdrawals for five other urban municipalities in the study area: Barons, Champion, Carmangay, Longview and Stavely (Table 2).

- **Rural Domestic Use**

About one third of the population within the study area resides in the rural areas. The primary source of water for rural domestic users is wells. The M.D. of Foothills uses 0.341 m^3/capita-day (75 igpd) as design criteria for rural domestic users. Rural domestic use includes household use and lawn and garden watering. The value of 0.341 m^3/capita-day was adopted as the average per capita water use (withdrawal) for all rural and hamlet users in the study area. The same value was used for the Eden Valley Indian Reserve.

- **Return Flow**

Return flow data for five urban centers in the study area was obtained from two sources -- a 1996 survey conducted by the Bow River Basin Water Council (BRBWC 1998), and directly from some of the towns. The results were as follows:

- High River (town only) 56% return flow
- Okotoks 65% return flow
- Black Diamond and Turner Valley 72% return flow
- Longview 56% return flow
- Nanton 63% return flow

The above percentages were used to estimate the volumes of return flow from the five communities. Return flows from the above communities are continuous throughout the year.

With regard to other communities (Table 2), a portion of Vulcan's treated effluent is used for irrigation. Some of it evaporates. Occasionally, there may be a release to Snake Creek (out of the study area). Return flow from Blackie is estimated by the Municipal District of Foothills to be about 70% of the water withdrawal[1]. Releases to a Frank Lake tributary are usually made in the spring and fall. Wastewater from Cayley, Carmangay, Champion and Stavely is normally consumed by effluent irrigation and/or

[1] Personal communication with Tom Gilliss, Water and Sewers, M. D. of Foothills.

evaporation. There may occasionally be a fall release of a small volume of treated effluent from these communities, but the amount of return flow would not be significant to the issues at hand.

Return flow from rural domestic users would be comprised of almost all household cooking and sanitary requirements, and none of the outside watering. It is estimated that about 75% of the rural domestic water withdrawal in the study area, primarily from groundwater, is returned to groundwater through septic fields.

Estimated return flows to the study area are summarized in Table 2.

- **Monthly Distribution of Demand and Return Flow**

Records and the literature show that the monthly distribution of urban and rural **domestic demand** (household plus outside watering) is similar in all communities. Typically, in the spring, fall and winter months, demands consist primarily of household cooking and sanitary requirements. In the summer months, lawn and garden watering becomes a factor and demand increases. Communities may have different commercial, institutional and industrial demands, which could result in variations in the monthly distribution of total water demands among the communities.

The monthly distribution of surface water **withdrawals and return flow** can vary substantially among communities depending on several factors, such as the source of supply, amount of storage available, and sewage treatment method. As discussed in the previous section, some communities have continuous return flows to the source stream; others have none. Some only discharge once or twice a year. The monthly distribution of withdrawals and return flows were developed for communities and rural domestic users based on information from past studies, and discussions with AENV municipal engineers and various town and rural municipality officials (Table 3). Wastewater volumes have considerably less monthly variation than withdrawals. Withdrawals increase significantly during the summer months primarily due to outside watering. Outside watering does not affect the volume of wastewater, and hence, return flows. All things considered, for those communities that have continuous return flows, it was decided to distribute wastewater volumes equally among all months.

Treated wastewater return flows to receiving water bodies are system-specific. Withdrawal and return flow information should be used with care in simulation modelling, keeping in mind the source of withdrawals and the receiving body for return flows.

Summary of Key Findings

- From the perspective of developing the Highwood Diversion Plan, the most significant municipal water user is the Town of High River. Considering only the town's requirements (not including Cargill, Mazeppa and the M.D. requirements), and assuming that withdrawals from all 10 production wells are equivalent to surface water withdrawals, river depletions during the critical July – August period would be about 0.111 m^3/s (about 4.0 cfs). Assuming only three of the 12 wells are fed from the Highwood River, the river depletions would be about 25% of that depletion rate.

- The Town of Vulcan is the largest mainstem municipal water user in the Little Bow River Basin. The Town will pump water from the Little Bow Reservoir to a raw water storage reservoir that is subject to evaporation losses that most other communities in the study area do not have. Issues related to Vulcan's water use are:

    - The frequency and duration of periods when Vulcan is dependent on river flows for its water supply. This will depend upon the frequency and magnitudes of severe drawdowns of the Little Bow River Reservoir.

- The flows required at Vulcan's intake to enable the Town to withdraw the water it requires during the severe reservoir drawdowns.

- The Town of Nanton makes a net flow contribution to mainstem Mosquito Creek. About 50% of its water supply in 2001 came from a spring and a well; the other 50% from Mosquito Creek. All of Nanton's treated wastewater is returned to Mosquito Creek. Town officials predict that in the future up to 80% of Nanton's water supply may be withdrawn from Mosquito Creek, substantially increasing the municipal water demand from the Creek.

- Rural domestic water use is not a significant factor in developing the Highwood Diversion Plan. Its consumptive use is small, and its linkage to flow in mainstem streams is uncertain, since most of the use is from groundwater.

References

Bow River Basin Water Council 1998. Survey of Urban Water Use Management in the Bow River Basin. Alberta Environment. Calgary, AB.

Environment Canada. 1999. Municipal Water Use Survey. Environment Canada. Hull, QC.

Hydroconsult 1999. Non-irrigation Consumptive Demand Projections – Little Bow Project EIA. Alberta Environment. Calgary, AB.

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Table 1 Projected population by community and sub-basin.

Location	1996 Census	2001 Census	Water Supply Source	Wastewater Disposal
SHEEP RIVER BASIN[1]				
Okotoks	8510	11664	Wells near the Sheep River.[3]	Continuous discharge to Sheep River.
Black Diamond	1811	1866	Wells near the Sheep River.[3]	Continuous discharge to Sheep River.
Turner Valley	1527	1608	Wells near the Sheep River.[3]	Continuous discharge to Sheep River.
Rural (59% of MD 31)	8045	9890	Primarily wells.	Primarily septic fields.
Subtotal	19893	25028		
HIGHWOOD RIVER BASIN[1]				
High River	7359	9345	Wells near the Highwood River.[4]	Continuous discharge to Frank Lake.
Longview	303	300	Wells near the Highwood River.[3]	Continuous discharge to Highwood River.
Eden Valley Reserve	432	509	Highwood River.	Septic fields.
Rural (25% of MD 31)	3448	4191	Primarily wells.	Primarily septic fields.
Subtotal	11542	14345		
Total Highwood	31435	39373		
MOSQUITO CREEK BASIN[1]				
Cayley	334	344	Women's Coulee (canal).	Evaporation and Women's Coulee (minimal).
Nanton	1665	1841	Mosquito Creek, a spring and a well.	Continuous discharge to Mosquito Creek.
Rural (15.5% of MD 26)	793	838	Primarily wells.	Primarily septic fields.
Subtotal	2792	3023		
UPPER LITTLE BOW BASIN[1]				
Vulcan	1537	1762	Little Bow River.	Evaporation, effluent irrigation, Snake Creek (minimal).
Blackie	301	310	Deep wells.	Evaporation. Frank Lake.
Rural (Vulcan County 2 density)	601	636	Primarily wells.	Primarily septic fields.
Subtotal	2439	2708		
LOWER LITTLE BOW BASIN[1]				
Carmangay	258	255	Little Bow River and supplemental wells.	Evaporation, effluent irrigation, Little Bow River (minimal).
Champion	362	355	Travers Reservoir and supplemental well.	Evaporation, effluent irrigation, Long Creek (minimal).
Barons	285	284	LNID Turin Canal.	Evaporation, effluent irrigation.
Stavely	453	442	Well.	Evaporation, Clear Brook (minimal).
Rural (Vulcan County 2 density)	1345	1403	Primarily wells.	Primarily septic fields.
Subtotal	2703	2739		
TOTAL LITTLE BOW[2]	7934	8470		

Notes:
1. Basin population based upon Census Canada data and Hydroconsult (1999) for rural densities.
2. Total Little Bow includes Upper and Lower Little Bow, and Mosquito Creek.
3. Wells are believed to be river fed.
4. At least 3 of High River's 12 production wells are river fed.

Table 2 Water use estimates for urban and rural municipalities in the study area.

Location	1999 Pop'n Estimate	1999 withdrawal dam^3	1999 withdrawal m^3/c-d	1999 Info Source	2001 Census	2001 Withdrawal dam^3	2001 Return %	2001 Return dam^3	2001 Cons Use dam^3
SHEEP RIVER BASIN									
Okotoks	(2001 data)		0.480	Town	11664	2043.5	65%	1328.3	715.2
Black Diamond	1844	348.2	0.517	Env Can	1866	352.4	72%	253.7	98.7
Turner Valley	1575	265.4	0.462	Env Can	1608	270.9	72%	195.0	75.9
Rural (59% of MD 31)			0.341		9890	1231.0	75%	923.3	307.8
Subtotal					25028	3897.8		2700.2	1197.6
HIGHWOOD RIVER BASIN									
High River	(3-year mean)		0.828	Town	9345	2824.2	55%	1553.3	1270.9
Longview	301		0.493		300	54.0	56%	30.2	23.8
Eden Valley Reserve -- Institutional						15.0	75%	11.3	3.7
-- Rural Domestic	477		0.341		509	63.4	75%	47.6	15.9
Rural (25% of MD 31)			0.341		4191	521.6	75%	391.2	130.4
Subtotal					14345	3463.2		2033.6	1444.7
TOTAL HIGHWOOD					39373	7361.0		4733.8	2642.2
MOSQUITO CREEK BASIN									
Cayley	340		0.341		344	42.8	insig.	0.0	42.8
Nanton	1768	292.0	0.452	Env Can	1841	304.0	63%	191.5	112.5
Rural (15.5% of MD 26)			0.341		838	104.3	75%	78.2	26.1
Subtotal					3023	451.1		269.7	181.4
UPPER LITTLE BOW BASIN									
Vulcan	1668	343.1	0.563	Env Can	1762	362.4	0%	0.0	362.4
Blackie	306		0.341		310	38.6	70%	27.0	11.6
Rural (Vulcan County 2 density)			0.341		636	79.2	75%	59.4	19.8
Subtotal					2708	480.1		86.4	393.8
LOWER LITTLE BOW BASIN									
Carmangay	256		0.493		255	45.9	insig.	0.0	45.9
Champion	358		0.493		355	63.9	insig.	0.0	63.9
Barons	284		0.493		284	51.1	0%	0.0	51.1
Stavely	446		0.493		442	79.5	insig.	0.0	79.5
Rural (Vulcan County 2 density)			0.341		1403	174.6	75%	131.0	43.7
Subtotal					2739	415.0		131.0	284.1
TOTAL LITTLE BOW[1]					8470	1346.2		487.1	859.2

Notes: 1. Total Little Bow includes Upper and Lower Little Bow, and Mosquito Creek.

2. Shaded values are based on mean recorded values for Okotoks, Black Diamond, Turner Valley, Nanton and Vulcan.

Table 3 Monthly distribution of municipal and rural domestic water supplies and return flows.

Community		Source or Water Body	Annual Volume[1] dam^3	Monthly Distribution (% of annual)[1] Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Okotoks	Withdrawal	Sheep R.	2044	6.5%	6.5%	6.5%	8.0%	9.0%	10.0%	10.5%	10.5%	9.5%	9.0%	7.0%	7.0%
	Return	Sheep R.	1328	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
B. Diamond	Withdrawal	Sheep R.	352	6.5%	6.5%	6.5%	8.0%	9.0%	10.0%	10.5%	10.5%	9.5%	9.0%	7.0%	7.0%
	Return	Sheep R.	254	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
T. Valley	Withdrawal	Sheep R.	271	6.5%	6.5%	6.5%	8.0%	9.0%	10.0%	10.5%	10.5%	9.5%	9.0%	7.0%	7.0%
	Return	Sheep R.	195	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
High River[2]	Withdrawal	Highwood R.	2824	6.5%	6.5%	6.5%	8.0%	9.0%	10.0%	10.5%	10.5%	9.5%	9.0%	7.0%	7.0%
	Return	Frank Lake	1553	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
Longview	Withdrawal	Highwood R.	54	6.5%	6.5%	6.5%	8.0%	9.0%	10.0%	10.5%	10.5%	9.5%	9.0%	7.0%	7.0%
	Return	Highwood R.	30	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
Eden Valley	Withdrawal	Highwood R.	15	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
		Wells	63	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Septic fields	62	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
Cayley	Withdrawal	Women's Co.	43					20.0%	17.5%	12.5%	12.5%	17.5%	20.0%		
	Return	Women's Co.		Insignificant volume.											
Nanton[3]	Withdrawal	Spring, well, res.	152	5.3%	5.3%	5.3%	12.5%	15.8%	12.5%	9.2%	7.9%	7.9%	7.9%	7.9%	7.9%
		Mosquito Cr.	152					16.0%	24.0%	10.0%	10.0%	16.0%	24.0%		
	Return	Mosquito Cr.	192	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%
Vulcan	Withdrawal	Little Bow R.	362					18.0%	23.0%	12.0%	12.0%	12.0%	23.0%		
	Return	Snake Cr.		Zero return to study area. Minimal return to Snake Creek.											
Blackie	Withdrawal	Wells	39	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Frank Lake	27				55.0%						45.0%		
Carmangay	Withdrawal	Little Bow R.	46	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Little Bow R.		Insignificant volume.											
Champion	Withdrawal	Travers Res.	64	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Travers Res.		Zero return to study area. Insignificant volume to Travers Reservoir.											
Barons	Withdrawal	Keho Lake	51	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return			Zero return to study area.											
Stavely	Withdrawal	Well	80	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Clear Brook		Insignificant volume.											
Rural Dom.[4]	Withdrawal	Wells	2111	6.6%	6.6%	6.6%	6.6%	6.6%	13.3%	13.3%	13.3%	7.3%	6.6%	6.6%	6.6%
	Return	Septic fields	1583	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%	8.3%

Notes:

1. Annual volume and monthly distribution are variable from year to year. Values shown are typical.
2. High River demand excludes supplies to Cargill Foods, Mazeppa Gas Plant and M.D. of Foothills.
3. In winter months when Nanton's water demand exceeds the supply available from the spring and well, water is drawn from storage reservoirs.
4. Rural domestic volumes are the totals for all sub-basins in the study area.

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Livestock Water Demand

Issues:
- What is the livestock population in the Highwood/Little Bow Mosquito Creek Basins?
- How much water do the livestock require in the study area?
- What is the monthly distribution of demand?

Discussion:

- **Introduction**

Secure sources of good quality water are essential for the important livestock industry in the study area. Water supplies well distributed within grazing lands enable sound range management practices. Feedlots and winter-feeding areas must have ready access to secure water supplies.

Common sources of stock water in the study area are wells, dugouts, small stock water dams on intermittent streams, and the streams themselves. Well-managed use of riparian areas and controlled access to streams is important to maintain healthy streams and riparian vegetation.

Stock water supplies are considered to be a high value use of water. The volume required is difficult to estimate. In a large basin, it is often considered to be low enough to be insignificant relative to other water uses, such as irrigation, municipal and industrial supplies. Unlike most other uses of water, not all water use for livestock purposes requires a licence under the *Water Act* or its predecessor, the *Water Resources Act*. This presents some challenges in determining actual use of water by livestock. In this study, an attempt is made to quantify the stock water demand based upon cattle populations to help to put it into perspective with other uses of water.

- **The Livestock Population**

Cow-calf operations and the feedlot industry clearly have the largest livestock water requirement in the study area. Cattle populations within the rural municipalities that make up portions of the study area are available from 1996 census data (Table 1). The census data includes domestic herds and the cattle that were in feedlots in the municipalities in May 1996.

Cattle populations within each sub-basin in the study area were estimated by prorating census data by the proportion of each rural municipality that is within the various sub-basins (Table 2). A separate estimate of the feeder population was developed based upon feedlots that have been identified and their respective capacities. Eleven feedlots have been identified in the study area. Capacity estimates are available for all but three feedlots. (The confidentially of information related to feedlot operations is respected.) The three missing capacities were assumed to be the average of the other eight. Note that the feeder population estimated from feedlot capacities is considerably higher than that based upon prorated data, implying a disproportionately high feedlot population in the study area as compared with the areas of the municipalities outside of the study area. The feeder population estimate and its distribution among the sub-basins based upon feedlot capacities were adopted for the purposes of water use estimates.

Table 1. Census data (1996) on cattle populations within rural municipalities.

Municipality	Domestic Herd: Beef Cows	Calves <1 yr	Bulls	Milk Cows	Total	Feeders: Heifers >1 yr	Steers >1 yr	Total	GRAND TOTAL
Foothills	46,699	64,727	3035	1369	114,461	39,090	15,709	54,799	169,260
Willow Creek	56,912	53,018	3436	3417	113,366	30,582	38,795	69,377	182,743
Ranchland	4400	4255	273		8,928	1614	2449	4063	12,991
Vulcan	25,838	23,519	1419	841	50,776	9210	17,304	26,514	77,290
Lethbridge	18,255	42,698	1614	8906	62,567	191,686	138,887	330,573	393,140

Notes: Census date: May 14, 1996.
Feeders not equal to feedlots populations. Includes backgrounding.

Table 2. Sub-basin cattle populations from prorated census data and feedlot capacities.

	Prorated from May 14, 1996 census data: B. Cows	Calves	Bulls	Milk	Feeders	Feeders - based on Feedlot Capacities
Sheep	14,010	19,418	911	411	16,440	10,000
Highwood	20,230	27,781	1313	575	23,584	94,000
Mosquito	11,530	12,453	714	554	13,769	17,000
Upper L. Bow	10,265	12,947	651	373	12,073	34,000
Lower L. Bow	16,498	15,260	968	850	19,125	0
GRAND TOTAL	72,533	87,860	4557	2762	84,991	155,000

Notes: Not all feedlot capacities are known. The capacities of three have been estimated.
Feeder population based on feedlot capacity was used for purposes of this study.
Feeder numbers in the shaded area were not used.

- **Annual Cattle Population Cycle**

During the spring and early summer, many of the cow-calf operators transport their cattle to grazing lands out of the basin. The cattle return home in the fall for winter-feeding and shelter during calving. The basin population, and hence water use, reflects that annual cycle. Most cow-calve producers sell calves at weaning to feedlot operators in fall and early winter. Annual beef cow and calf cycles have been assumed for the purposes of estimating basin stock water requirements. A typical cycle for the Mosquito Creek Sub-basin is shown in Table 3. The same cycle was assumed for the other sub-basins.

Feedlot populations also go through an annual cycle. Typically, feedlots are at or near capacity in the winter months, and at less than capacity during the summer months as finished cattle are sold. Feedlot water use does not vary significantly from month to month because of feeding patterns and weather variations (temperatures). The higher water requirements during the warm summer months offset the impact of lower populations. Hence, feedlot population fluctuations were not estimated.

Table 3. Cattle population annual cycle within the Mosquito Creek Sub-basin.

Months	Domestic Herd					Milk	Feedlot Cattle
	Cows		Calves				
	% in basin	No.	% in basin	No.	Bulls		
January	100%	14,413	25%	3892	714	554	17,000
February	100%	14,413	50%	7784	714	554	17,000
March	100%	14,413	75%	11,675	714	554	
April	100%	14,413	100%	15,567	714	554	
May	80%	11,530	80%	12,453	714	554	
June	40%	5765	40%	6227	714	554	Variable
July	40%	5765	40%	6227	714	554	
August	40%	5765	40%	6227	714	554	
September	40%	5765	40%	6227	714	554	
October	40%	5765	40%	6227	714	554	
November	100%	14,413	50%	7784	714	554	17,000
December	100%	14,413	0%	0	714	554	17,000

Note: The domestic herd population is based on May 1996 census data (shaded row). An estimated 20% of the domestic herd is on grazing lands out of the basin in May.

- **Water Requirements**

Consumptive water requirements for cattle vary depending on several factors, such as animal size, weather conditions, available shelter, and type of feed. Daily water requirements may vary from about 5.0 to 20.0 igpd for a full size beef cow. Alberta Agriculture, Food and Rural Development (AAFRD) recommends water consumption values to use for planning stock watering facilities (Table 4). They note that peak demands on hot summer days may exceed the listed values by 100 percent (AAFRD. 2000). AAFRD values were used to estimate stock water requirements in the study area for all cattle except for feeders. Monitored feedlot use is fairly consistent throughout the year, with higher summer requirements offset by lower cattle numbers in the feedlots. The actual average use is reportedly less than the published values. Based upon this input, a consumptive use value of 6.0 imperial gallons per day (27.3 l/d) for the full capacity of the feedlot was used to estimate feedlot water use for each month.

Table 4. Average daily water requirements.

Animal Type	Animal Size lbs	Water Requirements igpd	Comments
Feeders	550	4	Feeders on silage.
	900	7	Feeders on silage.
	1250	10	Feeders on silage.
Cows with calves	1300	12	On hay or pasture.
Dry cows	1300	10	On hay or pasture.
Calves	250	2	On hay or pasture.
Milk Cows	Holstein	30	On hay or pasture.

Note: 1.0 igpd = 4.455 l/d or 0.00455 m^3/d.

- **Sub-basin Water Requirements**

Cattle water requirements for each sub-basin were estimated based on the cattle populations and the foregoing average daily consumption rates. Livestock populations within the study area include a variety of other animals, such as hogs, chickens, turkeys, horses, sheep, and llamas. An inventory of most of these other types of livestock was compiled for the Little Bow River basin (Hydroconsult. 2001). An estimate of water use for these other types of livestock using AAFRD consumption rates came to about 7.5 percent of the cattle consumption estimate. For the purposes of this study, it was assumed that non-cattle livestock consumption would be about 10 percent of the cattle consumption.

Water licence listings include 280 surface stock water projects in the study area, which are primarily small storage projects on tributary streams. Storage projects have evaporation losses. These losses were included in the stock water consumptive use estimates for the sub-basins. Since summer evaporation losses would result in a depletion to an intermittent stream during the following spring runoff, the losses were assigned to the months of March and April.

The estimated sub-basin stock water requirements are provided in Table 5. These estimates are considered to be an improvement over the estimate provided by AMEC (2001). Improvements relate to consideration of the seasonal cycle of cow-calf operations, separate treatment of feedlot populations, and a better estimate of basin populations based upon census data for municipalities.

Summary of Key Findings

- Stock water requirements are highest in the Highwood River Basin. The Highwood Basin has the largest domestic herd and feedlot populations. Even at that, the stock water demand (1907 dam^3) in the Highwood Basin could be met with a year-round steady flow of 0.06 m^3/s (2.1 cfs).

  Comparable numbers for the other sub-basins are as follows:

  - Highwood 1907 dam^3 0.060 m^3/s (2.1 cfs)
  - Sheep 908 dam^3 0.030 m^3/s (1.0 cfs)
  - Mosquito Creek 809 dam^3 0.025 m^3/s (0.9 cfs)
  - Upper Little Bow 600 dam^3 0.018 m^3/s (0.7 cfs)
  - Lower Little Bow 473 dam^3 0.015 m^3/s (0.5 cfs)

- Stock water requirements are highest in the spring when cattle populations are at their peak in the basins and evaporation losses from impoundments on tributary streams are replaced during spring runoff. More importantly, demands are lowest in the critical summer months of July, August and September when streamflows are low and demands for other purposes are high. For instance, the estimated August stock water demands in the five sub-basins are:

  - Highwood 110 dam^3 0.041 m^3/s (1.5 cfs)
  - Sheep 26 dam^3 0.010 m^3/s (0.3 cfs)
  - Mosquito Creek 30 dam^3 0.011 m^3/s (0.4 cfs)
  - Upper Little Bow 44 dam^3 0.016 m^3/s (0.6 cfs)
  - Lower Little Bow 21 dam^3 0.008 m^3/s (0.3 cfs)

- Evaporation losses are a significant component of total livestock requirements in the Sheep River and Mosquito Creek sub-basins, being near 50 percent. Unused projects (if any) should be breached to reduce evaporation.

References:

AAFRD. 2000. Wells that last for generations. Edmonton, AB.

AMEC Earth and Environmental Ltd. 2001. Non-storage Options Assessments – Highwood Management Plan – Phase 1. AENV. Calgary, AB.

Hydroconsult. 2001. SSRB – Non-irrigation Water Use Forecasts. AENV. Calgary, AB.

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Table 5. Livestock water demand estimates (dam^3).

	Highwood Sub-basin				Sheep Sub-basin				Upper Little Bow Sub-basin				Lower Little Bow Sub-basin				Mosquito Sub-basin			
	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total
January	117.9	11.6		129.6	36.6	3.7		40.3	48.8	4.8		53.6	34.2	3.1		37.4	37.9	3.6		41.5
February	120.3	11.6		131.9	38.3	3.8		42.1	49.9	4.8		54.7	35.5	3.1		38.7	38.9	3.6		42.6
March	122.7	11.6	218	352.3	39.9	4.0	245	288.9	51.1	4.8	0	55.8	36.8	3.1	50	90.0	40.0	3.6	181	224.6
April	125.0	11.6	218	354.7	41.5	4.2	245	290.7	52.2	4.8	0	56.9	38.1	3.1	50	91.3	41.1	3.6	181	225.7
May	116.2	11.6		127.9	35.5	3.6		39.1	47.8	4.8		52.5	31.5	3.1		34.6	36.3	3.6		39.9
June	98.7	11.6		110.3	21.3	2.1		23.4	39.0	4.8		43.8	18.1	3.1		21.3	26.7	3.6		30.3
July	98.7	11.6		110.3	23.3	2.3		25.6	39.0	4.8		43.8	18.1	3.1		21.3	26.7	3.6		30.3
August	98.7	11.6		110.3	23.3	2.3		25.6	39.0	4.8		43.8	18.1	3.1		21.3	26.7	3.6		30.3
September	98.7	11.6		110.3	23.3	2.3		25.6	39.0	4.8		43.8	18.1	3.1		21.3	26.7	3.6		30.3
October	98.7	11.6		110.3	23.3	2.3		25.6	39.0	4.8		43.8	18.1	3.1		21.3	26.7	3.6		30.3
November	120.3	11.6		131.9	38.3	3.8		42.1	49.9	4.8		54.7	35.5	3.1		38.7	38.9	3.6		42.6
December	115.6	11.6		127.2	35.0	3.5		38.5	47.7	4.8		52.5	32.9	3.1		36.1	36.8	3.6		40.4
Totals	1331	139.5	436.0	1906.9	379.7	38.0	490.0	907.7	542.5	57.3		599.8	335.3	37.8	100.0	473.1	403.5	43.5	362.0	809.0

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Current Actual Water Use

Issues:

- What is the extent of current actual water use within the various sub-basins in the study area? And for what purposes?
- What is the monthly distribution of water use?
- What uses are most significant in the development of the Highwood Diversion Plan?

Discussion:

- **Introduction**

Water licences define the allocation, purpose and location of projects in the study area. The allocations provide an indication of the size of the projects. The licensed water allocation can be considered an upper limit of water use of the project. However, the entire allocation may not be used every year, depending on many factors, such as weather conditions, water availability, crop rotations, and economic circumstances. A review of reported actual water uses submitted by licensees indicated that actual withdrawals and consumptions are usually less than licensed withdrawals and consumptions by varying degrees depending on user category (Hydroconsult. 1999). Procedures for defining the allocation volume for licences have varied over the years. In recent years, water allocations for irrigation have been based upon high-side water demand situations so that the licensee has the potential to use his or her full requirements (subject to water availability and licence priorities) in years when it is most needed. For instance, irrigation district allocations have been based upon 90 percentile crop water requirements (hot, dry growing conditions).

Because of the continuing existence of riparian rights, not all water uses are reflected in the water licence database. The "household uses" and "traditional agriculture uses" (terms used in the *Water Act*) that are not included in the database are a small percentage of the licensed use.

- **Estimated Water Use**

Estimates of mean annual actual use for each purpose in the study area were based upon several purpose-specific factors and considerations. The results are summarized for each sub-basin in the study area in Tables 1, 2 and 3. Mainstem water demands are tabulated separately. Mainstem demands are most significant in developing the Highwood Diversion Plan (sidebar).

- **Irrigation**

Mean annual actual irrigation water use for the various irrigation blocks in the study area was computed from weekly water demand estimates prepared by Alberta Agriculture, Food and Rural Development (AAFRD). The AAFRD estimates were based upon a forage/grain crop mix (primarily), irrigation efficiencies based on the types of irrigation equipment used in the area, and on-farm management typical of irrigation projects within irrigation districts in similar agro-climatic zones.

Agro-climatic conditions for each irrigation block were taken from the closest node point in AAFRD's agro-climatic database (Irrigation Water Management Study Committee. 2002). Node points are on a 50 km grid throughout southern Alberta. Crop mixes were based upon a recent survey[2] of crops grown in the study area (Table 4). On-farm efficiencies were based on typical values for equipment used in the study area (Table 5). It was assumed that farmers irrigated to 80% of the optimum crop water requirements. This level of on-farm management is typical in irrigation districts with similar agro-climatic conditions and crop types.

It was assumed that all licensed projects were operating and irrigating the land areas specified in their licences. It is known that not all licensed projects are actually being irrigated. However, as long as licences exist and are in good standing, inactive projects could be re-activated in the future.

The irrigation demand is computed on a week-to-week basis for the 68-year study period. The demands shown in Tables 1, 2 and 3 are based on the average annual demand for the entire period, with a typical monthly distribution.

Mainstem Demands: For the purposes of this study, mainstem demands are those demands that have potential to reduce Highwood River flows in the critical fish habitat reach, Aldersyde to the Sheep River confluence. They include demands drawing water from the Highwood River, as well as demands along Women's Coulee, mainstem Mosquito Creek downstream of the Women's Coulee confluence, and mainstem Little Bow River upstream of the Little Bow River Reservoir (under construction). Generally, water users in these parts of the Little Bow Basin rely on diversions from the Highwood River to meet their needs. The Little Bow River downstream of the reservoir is significant, but less critical since users will be supplied with water from storage during low flow/high demand periods.

- **Livestock**

Estimates of actual withdrawals and consumptive uses (consumption plus losses) were based on domestic herd and feedlot cattle populations within the sub-basins of the study area, and average unit consumption rates. The procedures for estimating the cattle populations in the study area and the consumption rates are discussed in a separate Fact Sheet**, Livestock Water Use**. Ten percent of the computed value for cows, calves and feeders was added to account for other types of livestock (pigs, horses, chickens, sheep, etc.).

- **Other agricultural uses**

Other agricultural uses in the study area include minor uses related to fish farming, and small market gardens. Actual withdrawal and consumption were assumed to be 80 percent of licensed values (AMEC. 2001).

- **Municipal and rural domestic**

Per capita consumptive use computed from records of withdrawals and return flows for urban centres vary significantly because of factors such as infrastructure design, the extent of commercial, institutional and industrial uses, unrecorded amounts of water provided for domestic and other uses outside the urban center, unrecorded amounts of treated effluent used for irrigation or wildlife projects, and groundwater seepage into sewer systems (Hydroconsult. 2001). There are no records of uses by rural domestic users primarily supplied from groundwater. Procedures for estimating water use and return flows for communities and rural domestic users in the study area are discussed in a separate Fact Sheet, **Municipal and Rural Domestic Water Use**.

There are several unique situations in the study area that are noteworthy.

- The Town of High River draws water from 10 shallow production wells near the Highwood River to supply the needs of the town, near-by industries and rural domestic users. At least three of the wells are believed to be river-fed. There is uncertainty about the other seven wells. In simulation modeling, a conservative approach has been taken by assuming all wells are river-fed. This assumption may have to be examined in further detail by a hydro-geologist.

[2] Telephone surveys were conducted by Shirley Pickering, Diana Andrews and Gerry Porter.

- The Town of High River, Cargill Foods and the M. D. of Foothills withdraw water from the Highwood River (via three or more wells), and return their wastewater to Frank Lake in the Little Bow River Basin. Water is lost from Frank Lake through evaporation, transpiration, and spills to the Little Bow River. Spills are expected to occur in 40 to 60 percent of the years, in essence, representing a transfer of water from the Highwood River to the Little Bow River. Simulation modelling includes a water balance on Frank Lake to determine when spills would occur and their impacts.

- Several communities in the study area treat their wastewater in lagoon systems that have little or no return flow. If releases are necessary, they are made in fall and/or spring, both of which are outside the critical high demand-low flow period that is the focus for developing the Highwood Diversion Plan. Communities with mainstem water withdrawals and little or no return flow are Cayley, Carmangay, and Vulcan.

- Nanton withdraws its water from a spring, a well and Mosquito Creek. Its return flow is released to Mosquito creek on a continuous basis. Because its return flow to Mosquito Creek exceeds its withdrawal from the creek, the town is a net contributor to flow in Mosquito Creek.

- **Industrial**

The largest industrial water user in the study area is Cargill Foods. The Company's monthly use and return flow were estimated from records for years 2000 and 2001. Industrial users also include water flood projects for the petroleum industry, water bottling, aggregate washing and other categories. From discussions with industry officials, active water flood projects were estimated to consume about 60% of their licensed volume. Their water use is continuous throughout the year. Based upon a sample of water use returns, aggregate washing was estimated to use about 85% of their licensed consumptive use (withdrawal minus return flow) during the summer months, and water bottling and other categories were estimated to use about 65% of their licensed consumptive use (AMEC. 2001).

- **Recreation/Conservation**

Recreation projects in the study area include golf courses, parks and wetland projects. There are seven golf course irrigation licences and one park irrigation licence in the study area. One golf course has not been developed and is not included in the water use estimate. Golf course water use was estimated based upon the irrigation area and a unit irrigation demand 30% higher than the agricultural irrigation demand, to reflect the optimum level of growth. Park irrigation was assumed to be similar to agricultural irrigation.

There are two wetland licences in the study area – a licence to divert water from the Highwood River to Frank Lake (to supplement wastewater diversions) and a large, shallow depressional area on a tributary to the Lower Little Bow River west of Champion. Neither project has received much water in recent years. An arbitrary water use that may represent an average use over the years was assigned to each project. Both projects are active but they are unlikely to have an impact on the development of the Highwood Diversion Plan. The Frank Lake licence forbids diversions from the Highwood River during the critical July/August period, and the Champion project would likely impact mainstem flows only in wet years during the snowmelt period.

Key Findings

- Table 1, 2, 3 and 6 provide an estimate of actual water use in the study area. These tables provide a basis for developing demand files for various scenarios analyzed through simulation modeling. Scenario demand files may differ from the tables in this Fact Sheet, depending on several factors, such as,
  - whether or not inactive projects are included in the scenario,

- whether or not a fixed annual demand based on licence allocation or a variable demand based on crop requirements is used for irrigation,
- modelling considers only main stem demands (weekly),
- modelling considers unique demand requirements for each irrigation block in the study area (25 blocks for current conditions, 29 blocks with expansion), and
- modelling considers Highwood River instream requirements and Little Bow River and Mosquito Creek environmental flows. These requirements have not yet been finalized and are not included in this Fact Sheet.

- For purposes of developing the Highwood Diversion Plan, mainstem demands in July and August are most significant. During this period, irrigation demands are typically high, Highwood River flows are typically low and water temperatures are highest due to more frequent and prolonged high air temperatures. Critical fish habitat conditions can occasionally extend into June and September.

- Mainstem demands in all sub-basins are highest in the June, July, August period, primarily due to high irrigation demands. In the Highwood River Basin, the combined municipal and industrial demand is significant, comprising (potentially) almost 35% of the total July demand, primarily as a result of the Town of High River/Cargill Foods water supply system. (In this analysis it was assumed that all ten production wells are either fed from the river or are intercepting groundwater flows that would normally enter the river. This assumption may have to be examined.)

- Table 6 summarizes the estimated mainstem demands in July, the highest demand month, and annually. Irrigation is the predominant mainstem demand in all sub-basins. It is particularly high in the Upper and Lower Little Bow, and the Mosquito Creek Sub-basins, being in excess of 93% of the total July demand in those sub-basins. Fully meeting the estimated mainstem July demands in the various sub-basins would deplete Highwood River flows by the following amounts:

Highwood River Sub-basin	0.678 m^3/s
Upper Little Bow Sub-basin	0.293 m^3/s
Mosquito Creek Sub-basin (inc. W. Coulee)	0.398 m^3/s
Lower Little Bow Sub-basin (without L. Bow Res.)	2.329 m^3/s

References

AMEC. 2001. Non-storage Options Assessments – Highwood Management Plan: Phase I. Alberta Environment. Calgary, AB.

Hydroconsult 1999. Non-irrigation Consumptive Demand Projections – Little Bow Project EIA. Alberta Environment. Calgary, AB.

Hydroconsult. 2001. Non-irrigation Consumptive Demand Projections in the South Saskatchewan River Basin. Alberta Environment. Calgary, AB.

Irrigation Water Management Study Committee. 2002. Irrigation in the 21st Century Volume 2: On-farm Irrigation Water Demand. Alberta Irrigation Projects Association. Lethbridge, AB.

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Table 1. Estimates of actual 2001 consumptive water uses in the Highwood River Basin.

Highwood River Sub-basins (excluding Sheep River Sub-basin)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
		Mean Monthly Demand (dam^3)												
Upstream of Women's Coulee Diversion														
Irrigation	Mainstem				1.5	15.7	34.5	42.3	21.6	6.7	0.0			122.3
	Tributaries				20.9	223.4	492.2	603.9	308.9	96.0	0.0			1745.3
Stock[1]	Tributaries + GW	60.8	63.2	188.5	190.9	59.1	41.5	41.5	41.5	41.5	41.5	63.2	58.4	891.9
Other Agric														
Recreation														
Municipal	Towns, Villages	2.3	2.3	2.3	3.1	3.6	4.2	4.4	4.4	3.9	3.6	2.5	2.5	39.1
	Co-op	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0
	Rural Domestic[2]	2.0	2.0	2.0	2.0	2.0	36.9	36.9	36.9	5.6	2.0	2.0	2.0	132.1
Industrial	Injection	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	82.6	991.4
Totals	Mainstem	84.9	84.9	84.9	87.2	101.9	121.3	129.4	108.7	93.2	86.2	85.2	85.2	1152.8
	Tributaries + GW	62.8	65.2	190.6	213.9	284.6	570.8	682.5	387.5	143.2	43.6	65.2	60.5	2770.3
Women's Coulee Diversion to Little Bow Diversion														
Irrigation	Mainstem				10.8	115.7	255.0	312.8	160.0	49.7				904.2
Stock[3]	Mainstem	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	333.9
	Tributaries (losses only)			11.0	11.0									22.0
Other Agric														
Recreation	Golf				1.7	18.0	39.6	48.6	24.9	7.7	0.0			140.5
Municipal	High River	183.6	183.6	183.6	225.9	254.2	282.4	296.5	296.5	268.3	254.2	197.7	197.7	2824.0
	Foothills M.D.	4.0	4.0	4.0	4.9	5.5	6.1	6.4	6.4	5.8	5.5	4.3	4.3	60.8
Industrial	Mainstem	147.1	147.1	157.4	167.7	198.6	208.9	219.2	208.9	198.6	167.7	147.1	126.5	2094.3
Totals	Mainstem	362.4	362.4	372.7	438.8	619.7	819.7	911.3	724.5	557.9	455.1	376.8	356.2	6357.6
	Tributaries + GW			11.0	11.0									22.0
Little Bow Diversion to Aldersyde														
Irrigation	Mainstem				14.5	155.0	341.4	418.9	214.3	66.6	0.0			1210.6
	Tributaries				3.4	35.9	79.0	97.0	49.6	15.4	0.0			280.3
Stock[3]	Tributaries + GW	40.9	40.9	119.9	119.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	649.0
Other Agric														0.0
Recreation	Wetlands[4]				110.0	110.0	110.0							330.0
Municipal	Subdivisions	Included with rural domestic.												0.0
Industrial	Other	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	119.9
Totals	Mainstem	0.0	0.0	0.0	124.5	265.0	451.4	418.9	214.3	66.6	0.0	0.0	0.0	1540.6
	Tributaries + GW	50.9	50.9	129.9	133.3	86.8	130.0	147.9	100.5	66.3	50.9	50.9	50.9	1049.3
Aldersyde to Sheep River Confluence														
Irrigation	Mainstem				12.3	131.7	290.1	355.9	182.1	56.6	0.0			1028.7
Stock[3]	Tributaries (losses only)			2.5	2.5									
Other Agric														
Recreation	Golf	Not developed.												
Municipal	Subdivision	Water from High River.												
Industrial														
Totals	Mainstem	0.0	0.0	0.0	12.3	131.7	290.1	355.9	182.1	56.6	0.0	0.0	0.0	1028.7
	Tributaries + GW			2.5	2.5									5.0
Sheep River Confluence to Mouth														
Irrigation	Mainstem				1.2	13.0	28.7	35.2	18.0	5.6				101.8
Stock[3]	Tributaries (losses only)			3.0	3.0									6.0
Other Agric														
Recreation														
Municipal	Subdivision	Included with rural domestic.												
Industrial														
Totals	Mainstem	0.0	0.0	0.0	1.2	13.0	28.7	35.2	18.0	5.6	0.0	0.0	0.0	101.8
	Tributaries + GW			3.0	3.0									6.0
Basin Total	Mainstem	447.3	447.3	457.6	664.1	1131.3	1711.2	1850.7	1247.6	779.9	541.4	462.0	441.4	10181.6
	Tributaries + GW	113.8	116.1	337.0	363.7	371.3	700.7	830.4	488.0	209.5	94.5	116.1	111.4	3852.5

Notes:

1. Domestic herd stock water use for the entire basin is included in the value noted for Upstream of Women's Coulee Diversion. Feedlot water demand is noted in the appropriate sub-basin.
2. Rural domestic water use for the entire basin is included in the value noted for Upstream of Women's Coulee Diversion.
3. Stock water values noted are for feedlots and losses on surface water projects within the sub-basin.
4. Annual diversion to the Frank Lake wetland has varied between zero and 1100 dam^3.

Table 2. Estimates of actual 2001 consumptive water uses in the Sheep River Basin.

Sheep River Sub-basin		Mean Monthly Demand (dam^3)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sheep River Sub-basin														
Irrigation	**Mainstem**				**11.4**	**121.4**	**267.4**	**328.0**	**167.8**	**52.1**				**948.1**
Stock	Tributaries + GW	40.3	42.1	288.9	290.7	39.1	23.4	25.6	25.6	25.6	25.6	42.1	38.5	907.7
Other Agric	**Gardens**				**1.5**	**15.8**	**34.8**	**42.7**	**21.8**	**6.8**				**123.4**
	Fish	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0
Recreation	**Golf**				**3.1**	**33.6**	**74.0**	**90.8**	**46.4**	**14.4**				**262.4**
	Parks (GW)					1.5	1.5	1.5	1.5	1.5	1.5			9.2
Municipal	**Towns, Villages**	**83.4**	**83.4**	**83.4**	**122.7**	**148.9**	**175.1**	**188.2**	**188.2**	**162.0**	**148.9**	**96.5**	**96.5**	**1577.2**
	Co-ops	**2.8**	**2.8**	**2.9**	**2.9**	**2.9**	**5.7**	**5.7**	**5.7**	**3.2**	**2.9**	**2.9**	**2.8**	**43.2**
	Schools (GW)	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.2	0.2	0.2	0.2	1.6
	Camps (GW)					0.1	0.1	0.1	0.1	0.1	0.1			0.3
	Rural Domestic	4.3	4.3	4.3	4.3	4.3	86.8	86.8	86.8	12.9	4.3	4.3	4.3	307.7
Industrial	**Injection**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**35.7**	**428.8**
	Agg Wash					**8.7**	**8.7**	**8.8**	**8.8**	**8.7**	**8.7**			**52.4**
	(Trib + GW)	3.3	3.3	3.3	3.3	4.2	4.2	4.2	4.2	4.2	4.2	3.3	3.3	45.3
Totals	**Mainstem**	**121.9**	**121.9**	**122.0**	**177.4**	**367.0**	**601.4**	**700.0**	**474.5**	**283.0**	**196.2**	**135.1**	**135.0**	**3435.5**
	Tributaries + GW	48.2	50.0	296.8	298.6	49.4	116.3	118.3	118.3	44.6	36.0	50.0	46.4	1272.7

Table 3. Estimates of actual 2001 consumptive water uses in the Little Bow River Basin.

Little Bow River Sub-basins		Mean Monthly Demand (dam^3)												Total
(including Mosquito Cr.)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Upper Little Bow Sub-basin														
Irrigation	**Mainstem**				**19.7**	**278.2**	**552.4**	**739.8**	**317.6**	**53.3**	**13.8**			**1974.8**
	Tributaries				0.1	1.6	3.2	4.3	1.9	0.3	0.1			11.5
Stock	Tributaries + GW	53.6	54.7	55.8	56.9	52.5	43.8	43.8	43.8	43.8	43.8	54.7	52.5	599.8
Other Agric (GW)					0.0	0.7	1.4	1.8	0.8	0.1	0.0			4.9
Recreation														
Municipal	**Mainstem**					**65.2**	**83.3**	**43.4**	**43.4**	**43.4**	**83.3**			**362.0**
	(GW)	2.6	2.6	2.6	2.6	2.6	5.2	5.2	5.2	2.8	2.6	2.6	2.6	39.0
RF to Frank L.[1]		-129.59	-129.59	-129.59	-144.44	-129.59	-129.59	-129.59	-129.59	-129.59	-141.74	-129.59	-129.59	-1582.1
	Co-op	**0.9**	**0.9**	**0.9**	**1.0**	**1.0**	**1.8**	**1.8**	**1.8**	**1.0**	**0.9**	**0.9**	**0.9**	**13.8**
	Rural Domestic	0.3	0.3	0.3	0.3	0.3	5.6	5.6	5.6	0.8	0.3	0.3	0.3	19.8
Industrial	Other (GW)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	24.0
RF to Frank L.[1]		-139.87	-139.87	-149.86	-159.86	-189.83	-199.82	-209.81	-199.82	-189.83	-159.86	-139.87	-119.89	-1998.2
Totals	**Mainstem**	**0.9**	**0.9**	**0.9**	**20.7**	**344.3**	**637.4**	**785.0**	**362.8**	**97.7**	**98.0**	**0.9**	**0.9**	**2350.5**
	Tributaries + GW	58.5	59.6	60.7	62.0	59.7	61.1	62.7	59.2	49.9	48.8	59.6	57.4	699.1
	RF to Frank L.[1]	-269.5	-269.5	-279.5	-304.3	-319.4	-329.4	-339.4	-329.4	-319.4	-301.6	-269.5	-249.5	-3580.3
Lower Little Bow Sub-basin														
Irrigation	**Mainstem**				**137.5**	**1481.7**	**4567.4**	**6201.9**	**2612.1**	**198.6**	**91.7**			**15290.9**
	Tributaries				1.6	17.3	53.3	72.4	30.5	2.3	1.1			178.6
Stock	Tributaries + GW	37.4	38.7	90.0	91.3	34.6	21.3	21.3	21.3	21.3	21.3	38.7	36.1	473.1
Other Agric	Fish			8.4	8.4									16.8
Recreation	Wetland			127.3	127.3									254.5
Municipal	**Towns, villages**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**6.1**	**6.1**	**6.1**	**3.4**	**3.0**	**3.0**	**3.0**	**46.0**
	(GW)	5.3	5.3	5.3	5.3	5.3	10.6	10.6	10.6	5.8	5.3	5.3	5.3	80.0
	Co-ops	**14.3**	**14.3**	**14.3**	**14.3**	**14.3**	**28.7**	**28.7**	**28.7**	**15.8**	**14.3**	**14.3**	**14.3**	**216.0**
	Rural Domestic	0.6	0.6	0.6	0.6	0.6	12.3	12.3	12.3	1.8	0.6	0.6	0.6	43.7
Industrial	Bottling (GW)	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	49.7
Totals	**Mainstem**	**17.3**	**17.3**	**17.3**	**154.8**	**1499.0**	**4602.3**	**6236.7**	**2647.0**	**217.7**	**108.9**	**17.3**	**17.3**	**15552.9**
	Tributaries + GW	47.4	48.7	235.7	238.6	62.0	101.7	120.8	78.9	35.4	32.4	48.7	46.1	1096.4
Mosquito Creek Upstream of Women's Coulee														
Irrigation					4.0	36.7	75.3	99.5	42.6	9.4	0.5			268.1
Stock[2]	Tributaries + GW	27.6	28.7	190.0	191.1	26.0	16.4	16.4	16.4	16.4	16.4	28.7	26.5	600.6
Other Agric														
Recreation														
Municipal	Rural Domestic[3]	0.4	0.4	0.4	0.4	0.4	7.4	7.4	7.4	1.1	0.4	0.4	0.4	26.1
Industrial														
Totals		28.0	29.0	190.4	195.5	63.1	99.1	123.2	66.4	26.9	17.3	29.0	26.9	894.8
Women's Coulee														
Irrigation	**Mainstem**				**5.7**	**52.4**	**107.5**	**141.9**	**60.8**	**13.4**	**0.8**			**382.4**
Stock														
Other Agric														
Recreation														
Municipal	**Mainstem**					**8.6**	**7.5**	**5.4**	**5.4**	**7.5**	**8.6**			**43.0**
Industrial														
Totals	**Mainstem**	**0.0**	**0.0**	**0.0**	**5.7**	**61.0**	**115.0**	**147.2**	**66.2**	**20.9**	**9.4**	**0.0**	**0.0**	**425.4**
Mosquito Creek Downstream of Women's Coulee														
Irrigation	**Mainstem**				**34.5**	**314.7**	**645.5**	**852.3**	**365.3**	**80.4**	**4.6**			**2297.2**
Stock[4]	Tributaries + GW	13.9	13.9	34.6	34.6	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	208.4
Other Agric														0.0
Recreation	**Golf**				**1.9**	**17.6**	**36.2**	**47.8**	**20.5**	**4.5**	**0.3**			**128.8**
Municipal[5]	**Mainstem**	**-12.3**	**-12.3**	**-12.3**	**-12.3**	**5.6**	**15.5**	**-5.7**	**-5.7**	**3.9**	**19.0**	**-15.5**	**-15.5**	**-47.5**
	Tributary (spring)	4.0	4.0	4.0	15.0	20.0	15.0	10.0	8.0	8.0	8.0	8.0	8.0	112.0
	GW	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	48.0
Industrial	**Agg Wash**					**24.4**	**24.5**	**24.5**	**24.5**	**24.5**	**24.4**			**146.8**
	Other					1.5	1.5	1.5	1.5	1.5	1.5			9.1
	Other (GW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.4
Totals	**Mainstem**	**-12.3**	**-12.3**	**-12.3**	**24.1**	**362.4**	**721.7**	**918.9**	**404.5**	**113.3**	**48.3**	**-15.5**	**-15.5**	**2525.4**
	Tributaries + GW	22.4	22.4	43.1	54.1	40.0	35.0	30.0	28.0	28.0	28.0	26.4	26.4	383.8
Basin Total	**Mainstem**	**5.9**	**5.9**	**5.9**	**205.4**	**2266.7**	**6076.4**	**8087.8**	**3480.5**	**449.6**	**264.5**	**2.7**	**2.7**	**20854.2**
	Tributaries + GW	156.3	159.8	529.9	550.1	224.7	296.9	336.7	232.4	140.2	126.4	163.8	156.8	3074.1
	RF to Frank L.	-269.5	-269.5	-279.5	-304.3	-319.4	-329.4	-339.4	-329.4	-319.4	-301.6	-269.5	-249.5	-3580.3

Notes:
1. Return flow to Frank Lake is from the Town of High River, Cargill Foods and the M. D. of Foothills, all of which obtain their water from the Highwood River, and the Hamlet of Blackie, which obtains its water from wells.
2. Domestic herd stock water use for the entire Mosquito Creek Sub-basin is included in the value noted for Upstream of Women's Coulee. Feedlot water demand is noted in the appropriate sub-basin.
3. Rural domestic water use for the entire Mosquito Creek Sub-basin is included in the value noted for Upstream of Women's Coulee.
4. Stock water values noted are for feedlots and losses on surface water projects within the sub-basin.
5. The Town of Nanton obtains its water from a spring, a well and Mosquito Creek. Its entire return flow is released to Mosquito Creek.

Table 4. Crop mixes used for irrigation water demand estimates.

Block	Irrigated Area hectares	Crop Type -- hectares												
		alfalfa 3-cut	alfalfa 2-cut	alfalfa hay	barley silage	tame pasture	soft wheat	duram wheat	barley	malt barley	rye	canola	mint	market gardens	nursery
Highwood Basin														
U/S LB Div	539.5			392.0					25.9	121.5					
LB Div - A	492.5		105.3	228.4	28.8			52.7	77.4						
A - SR	148.6			139.3										8.1	1.6
SR - M	552.0		60.75	250.7		133.7			96.4					10.5	
Total	1732.6		166.05	1010.5	28.8	133.7		52.7	199.7	121.5				18.6	1.6
% of Total	100.0%		9.6%	58.3%	1.7%	7.7%		3.0%	11.5%	7.0%				1.1%	0.1%
Upper Little Bow															
	640.3			269.7			221.1		149.9						
Mosquito Creek															
	725.4	129.6				77.4	259.2		259.2						
Lower Little Bow															
	4472.0	1342.6					1342.6		1342.6		157.5	179.4	107.3		
Total	5837.7	1472.2		269.7		77.4	1822.9		1751.6		157.5	179.4	107.3		
% of Total	100.0%	25.2%		4.6%		1.3%	31.2%		30.0%		2.7%	3.1%	1.8%		

Key to Highwood River reaches:

U/S LB Div	Upstream of Little Bow Diversion
LB Div - A	Little Bow Diversion to Aldersyde
A - SR	Aldersyde to Sheep River confluence
SR - M	Sheep River confluence to mouth

Table 5. On-farm irrigation equipment mixes and efficiencies used for irrigation water demand estimates.

Block	Irrigated Area ha	On-farm Irrigation Methods / Representative Efficiencies									Weighted
		Flood-U 35%	SS 65%	VG 65%	HM 65%	WM-2L 68%	WM-4L 68%	P-HP 74%	P-LP 80%	Micro 90%	Mean Efficiency
		Area (ha)									
Highwood Basin											
U/S LB Div	372.6	36.9				20.4		279.5	35.5		70%
LB Div - A	492.5		45.4			110.6		97.2	239.4		75%
A - SR	148.6					75.3		64.0		9.7	72%
SR - M	552			108.8	60.5	165.6		203.9		10.5	70%
Total	1565.7	36.9	45.4	108.8	60.5	371.9		644.6	274.8	20.2	72%
Upper Little Bow											
363	640.3					120.7	112.6		407.4		76%
Mosquito Creek											
365	725.4				77.4		364.5		283.5		72%
Lower Little Bow											
364	4472.0						887.8	1075.3	2509.0		76%
Total	5837.7				77.4	120.7	1364.9	1075.3	3199.9		76%

Key to irrigation methods:

Flood-U	Flood -- undeveloped
SS	Sprinkler -- solid set
VG	Sprinkler -- volume gun
HM	Sprinkler -- hand move
WM-2L	Sprinkler -- wheel move -- 2 laterals
WM-4L	Sprinkler -- wheel move -- 4 laterals
P-HP	Sprinkler -- pivot -- high pressure
P-LP	Sprinkler -- pivot -- low pressure
Micro	Micro spray or drip

Key to Highwood River reaches:

U/S LB Div	Upstream of Little Bow Diversion
LB Div - A	Little Bow Diversion to Aldersyde
A - SR	Aldersyde to Sheep River confluence
SR - M	Sheep River confluence to mouth

Table 6. Summary of estimated peak monthly (July) and annual mainstem water uses.

Purpose	Highwood River Mainstem[1]				Upper L. Bow R. Mainstem				Women's Co/Mosquito Mainstem[2]				Lower L. Bow Mainstem			
	July		Annual		July		Annual		July		Annual		July		Annual	
	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%
Irrigation	1129.9	62.2%	3265.8	32.5%	739.8	94.2%	1974.7	84.0%	994.2	93.2%	2679.6	90.8%	6201.9	99.4%	15290.9	98.3%
Stock	27.8	1.5%	333.9	3.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other Agric	0.0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Recreation	48.6	2.7%	470.5	4.7%	0	0.0%	0	0.0%	47.8	4.5%	128.8	4.4%	0	0.0%	0	0.0%
Municipal	307.3	16.9%	2899.8	28.8%	45.2	5.8%	375.8	16.0%	-0.3	0.0%	-4.5	-0.2%	34.8	0.6%	262	1.7%
Industrial	301.8	16.6%	3085.7	30.7%	0	0.0%	0	0.0%	24.5	2.3%	146.8	5.0%	0	0.0%	0	0.0%
Totals	1815.5	100.0%	10055.6	100.0%	785.0	100.0%	2350.5	100.0%	1066.2	100.0%	2950.7	100.0%	6236.7	100.0%	15552.9	100.0%
Totals (m^3/s)	0.678		0.319		0.293		0.075		0.398		0.094		2.329		0.493	

[1] Includes all Highwood River mainstem uses upstream of the confluence with the Sheep River.

[2] Does not include any Mosquito Creek uses upstream of the confluence with Women's Coulee.

Technical Note

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Natural Flow Database and Simulation Model Configuration

Issues:
- Why are natural flows needed?
- How were natural flows computed?
- Is the natural flow database adequate to address issues in the Highwood/Little Bow/Mosquito Creek system?
- Is the model configuration adequate to address the issues?

Discussion:

- Why are natural flows needed?

The performance of the Highwood/Little Bow/Mosquito Creek system during droughts is a key factor in determining the impacts of a water management scenario. A scenario is a representation of existing or future water management options, including demands, priorities, operating policies, structural measures, and non-structural measures. The characteristics and impacts of droughts on large water management systems, such as exist in the South Saskatchewan River Basin (SSRB), are often addressed through simulation modelling using a historical period of stream flow and weather conditions. The approach infers that the performance of the system over a lengthy period of recorded conditions, that includes representative flood and drought periods, provides an insight into how well the system will perform in the future.

Recorded data for most hydrometric stations in the Highwood/Little Bow/Mosquito Creek system cannot be used directly in the model since they reflect a water use pattern that has been changing continuously throughout the recorded period. To be useful for simulation modelling, recorded flows are adjusted to provide a more consistent database by removing the influence of some of the larger human interventions in the hydrologic regime. The current level of water use and a variety of future options can then be superimposed on the water supply data to determine the performance of the system for various scenarios of water management.

- How were natural flows computed?

Weekly natural flows for the entire SSRB for the period 1912 to 1995 have been computed using the Project Depletion Method that has been used by water management agencies on the Prairies since the 1960s. Simply put, the method involves adding recorded upstream diversions (uses or regulations) to recorded flows at hydrometric stations to remove the effects of human interventions. A consistent, systematic procedure was used, and continues to be used, for organizing, storing and publishing the data.
- A-Files – Recorded flows at hydrometric stations.
- J-Files – Weekly adjustments to account for diversions upstream of each A-File station.
- B-Files – Reconstructed natural flows at hydrometric stations for the period of record.
- C-Files – Natural flows at the hydrometric stations for the full period 1912 to 1995.
- G-Files – Natural flows at ungauged points-of-interest for modeling purposes

The natural flow database for the Highwood/Little Bow/Mosquito Creek system consisted of weekly flows for the period 1928 to 1995 (Figure 1). Development of the database involved estimating diversions and some water uses, filling in data gaps and extending records, and estimating flow at ungauged locations. Historical uses for "minor" projects, such as stockwater, domestic, municipal, and industrial uses, could not be reconstructed for the historical period with a reasonable degree of accuracy. They were not included in the natural flow computations.

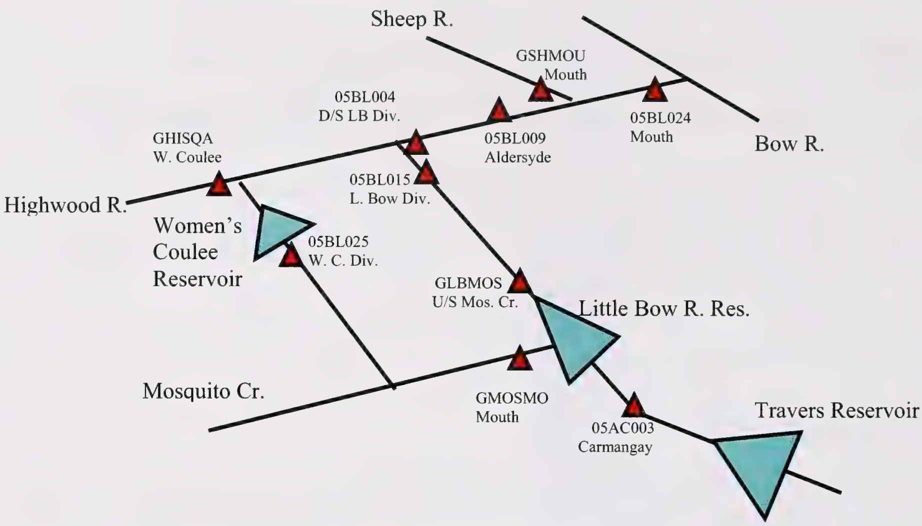


Figure 1. Natural flow database for the Highwood/Little Bow/Mosquito Creek system.

- Is the natural flow database adequate to address issues in the Highwood/Little Bow/Mosquito Creek system?

There are several issues related to the accuracy of the reconstruction of natural flows.

1. Some Withdrawal Uses Not Considered

Withdrawal uses not accounted for in reconstructing Highwood River natural flows include relatively small domestic and stockwatering uses, as well as some larger uses such as municipal uses for Okotoks and High River, industrial uses such as Cargill Foods Ltd. meat packing plant, and private irrigation uses for 1566 ha of land in the Highwood (and Sheep) River Basin. Consumptive use for mainstem irrigation projects in the Little Bow and Mosquito Creek Basins was considered. Other minor uses in these basins were not considered. The implications to the database, and to the accuracy and interpretation of model results of not considering all uses in the reconstruction of natural flows were analyzed.

Based upon estimates of uses not considered (AMEC 2001), conclusions are as follows.

- Not including all uses in the natural flow computations for the Highwood River network is not a significant issue. The modeling error due to the uses not considered would be small in relation to the flow of the Highwood River. The error would be on the conservative side, that is, there would be slightly more water available than the model would indicate since the computed natural flow considering all uses would be slightly higher, particularly in the latter part of the study period. The computational effort necessary to improve the database by estimating the minor uses for the 68-year period is not warranted.

- With regard to the Little Bow basin, uses not considered in the natural flow computations consist primarily of groundwater withdrawals and tributary uses for stock, rural domestic and a small amount of irrigation. No change in the natural flow computations is recommended for three reasons.
  - The linkage between mainstem flow and groundwater use and use on intermittent tributary streams is uncertain.
  - Tributary uses would normally affect mainstem flows only during the spring runoff season, which is outside the season of primary interest in the Highwood/Little Bow analysis.
  - Uses not considered would be small relative to the total flow available for use in the Little Bow River Basin. Not considering these uses in the natural flow computations would not result in a significant modeling error.

Modeling error becomes even less significant if outputs of various scenarios are evaluated relative to other scenarios rather than on an absolute value basis. This is usually facilitated by defining a base case scenario (which could be current conditions) to serve as a basis for comparison.

2. Land Use Changes Not Considered

Land use changes between years 1928 and 1995, such as land clearing, cultivation of farmland, drainage, forestry practices, urban development and construction of roads, railways and canals, have undoubtedly affected flows in the Highwood/Little Bow/Mosquito Creek system. Some changes would increase streamflows; others would decrease streamflows. The timing of surface water flows would be altered. These changes are gradual and subtle, and are reflected in the recorded data. The gradual changes may introduce a measure of non-homogeneity in the database, in that the statistical characteristics of a recent sample of the 1928 to 1995 database may be slightly different than an earlier part of the database. However, it is impossible to track and quantify the impacts of land use changes with our current tools and data. An attempt to do so would be expensive and time-consuming and may result in more error in the data set than accepting the data as it is.

3. Natural Spills from Highwood River

There is a long history of man's attempts to reduce property damage during flood events by preventing southward spills (overland flows) from the Highwood River to the Little Bow River. In spite of such attempts spills have occurred as recently as 1995. Spills would undoubtedly have been larger in magnitude and more frequent had the flood control works not been constructed. The computed natural flows do not reflect the frequency and magnitude of spills that would have occurred under actual natural conditions. Because flood control works have been in place during the entire study period, recorded flows represent consistent (approximately) flood control measures. It is therefore unlikely that a significant non-homogeneity would be in the data due to attempts to control flooding. Even if there were non-homogeneity, it would only affect high flow periods when water supply is not a concern.

4. Channel Losses

Channel losses, sometimes referred to as conveyance losses or carriage losses, result from five hydrologic processes – channel priming, bank storage, seepage, evaporation and transpiration.

Channel priming is most significant when water is released into a dry channel. Water is lost through seepage to fill voids in unsaturated substrate materials in the channel bed, and through filling storage in natural potholes, oxbows, depressions and beaver dams. Priming losses can be substantial, although short term. Bank storage losses occur when a rise in stream stage (water level) causes water to move from the stream into its banks. Streambank storage becomes a source of water for riparian vegetation. Whatever amount is not consumed by vegetation usually returns to the stream within days or weeks following a drop in stage.

Seepage on some streams and canals can be significant, but as a general rule steady state seepage losses in natural channels are small. Natural channel sediments and decayed vegetation tend to seal the beds of natural channels that are not actively degrading. Seepage to shallow aquifers that does occur in some reaches is often recovered as groundwater inflows in a downstream reach.

Evaporation from open water surfaces is always a concern in our semi-arid climate, since it represents water lost to the system without a return or benefit. Evaporation from streams is usually small due to the relatively small surface area. Evaporation is relatively easy to estimate based upon exposed surface area, evaporation and precipitation. Average evaporation from a 20 m wide channel in the study area would vary from about 4.0 dam^3/km/year near High River area to about 7.0 dam^3/km/year near Carmangay area.

Transpiration takes place from plants growing within or adjacent to the channel. Phreatophytes, plants with roots extending to or near the water table, are particularly adept at using water that either originates from streamflow or that would contribute to streamflow in the absence of riparian vegetation. The impacts of transpiration from riparian vegetation are stream-specific, depending on the amount and type of vegetation, and climatic conditions. Consumption by certain types of phreatophytes along a stream in south-central Saskatchewan was recorded to range from 600 to over 1000 mm over a June to September period. In contrast to evaporation losses, there is a return on the investment of transpiration losses. That return is related to the lush green riparian vegetation and its associated wildlife habitat, water quality, fishery, and aesthetic benefits.

Quantification of channel losses is stream-specific and best determined by monitoring controlled releases from reservoirs. Results from limited studies that have been conducted in Alberta and Saskatchewan are provided in Table 1.

All components of channel losses are inherent in recorded streamflow data. Channel losses in the natural flow computations for the Highwood/Little Bow/Mosquito Creek system is a non-issue, primarily because such losses are reflected in the recorded flows upon which the natural flow computations are based. From a water management perspective, channel losses may be significant if one of the objectives for a portion of the year is to simply maintain a live stream, or if the margin of error in delivering water to meet certain needs is very small. Channel losses are best determined by site-specific monitoring under controlled conditions, rather than theoretical computations or extrapolations from other streams.

Table 1. Summary of findings of channel loss studies conducted in Alberta and Saskatchewan.[1]

Channel Loss Component	Rate of Loss	Comments
Priming and bank storage	1.4 dam^3/km/day 1.23 dam^3/km/day	Berry Creek. Mostly bank storage, much of which would be recovered later. Short-term loss.
Seepage	0.13 dam^3/km/day	Berry Creek. Localized 10.5 km reach. Other reaches (48 km) – zero seepage loss.
Evaporation	0.15 dam^3/km/day	Based upon 20 m wide channel in southern Saskatchewan or Alberta.
Transpiration	0.15 dam^3/km/day	Based upon 50 m wide phreatophyte zone in southern Saskatchewan.

[1]Sources: Rozeboom. 1985 and 1986.

5. Filling Data Gaps, Extensions of the Data and Estimating Flow at Ungauged Sites

The methodologies used for filling data gaps, data extensions and estimating flows at ungauged sites are all standard procedures. The regression coefficients are high, indicating a good level of accuracy. (Regression coefficients provide a measure of the strength of a relationship between two or more variables.)

6. Use of Streamflow Data in the WRMM Model

- Inflow to the Little Bow River Reservoir -- In the current model set-up, the computed natural flow of the Little Bow River at Carmangay (C05AC003, or C-File data for Station 05AC003 (Figure 1)) is assumed to enter the Little Bow River Reservoir. This would provide higher inflows to the reservoir than would actually be available, the difference being the local runoff between the dam and Carmangay. The 68-year mean annual natural local runoff in this reach, computed as the Little Bow at Carmangay minus the Little Bow above the confluence with Mosquito Creek (GLBMOS) minus Mosquito Creek near the mouth (GMOSMO), is about 4400 dam^3. During the critically low runoff period, 1982 to 1988, the average annual local runoff has been estimated to be about 1200 dam^3. With the Little Bow River Dam in place and the current model configuration, this water would be stored during spring runoff and released later in the year to meet consumptive needs during the high demand period, resulting in an error in the water supply and demand balance. While this local runoff is not a large amount of water, the configuration could be easily corrected by inserting a node in the reach between the dam and Travers with appropriate demands and inflows.

  It is recommended that the inflow to the reservoir be reduced to the sum of the Little Bow above the confluence with Mosquito Creek and Mosquito Creek near the mouth.

- Local runoff between Carmangay and Travers Reservoir – In the current model set-up, the local runoff between Carmangay and Travers Reservoir is not accounted for. While the drainage area in this reach is significant, most of the runoff would be generated by the Long Coulee system and enter the Little Bow immediately upstream of Travers Reservoir. As such, and because of the timing of runoff, the local contribution would not be available for meeting consumptive needs. No change is recommended.

7. Model Configuration

- The model configuration does not include a reservoir at Frank Lake. Under the new management regime for Frank Lake, spills will be much more common than under natural conditions, estimated to be on an average frequency of 40 to 60 percent of the years (Golder Associates Ltd. 1997; Figliuzzi 1995). Spills of 3300 and 5800 dam^3 were recorded in 1996 and 1997 respectively. It spilled again in 2000.

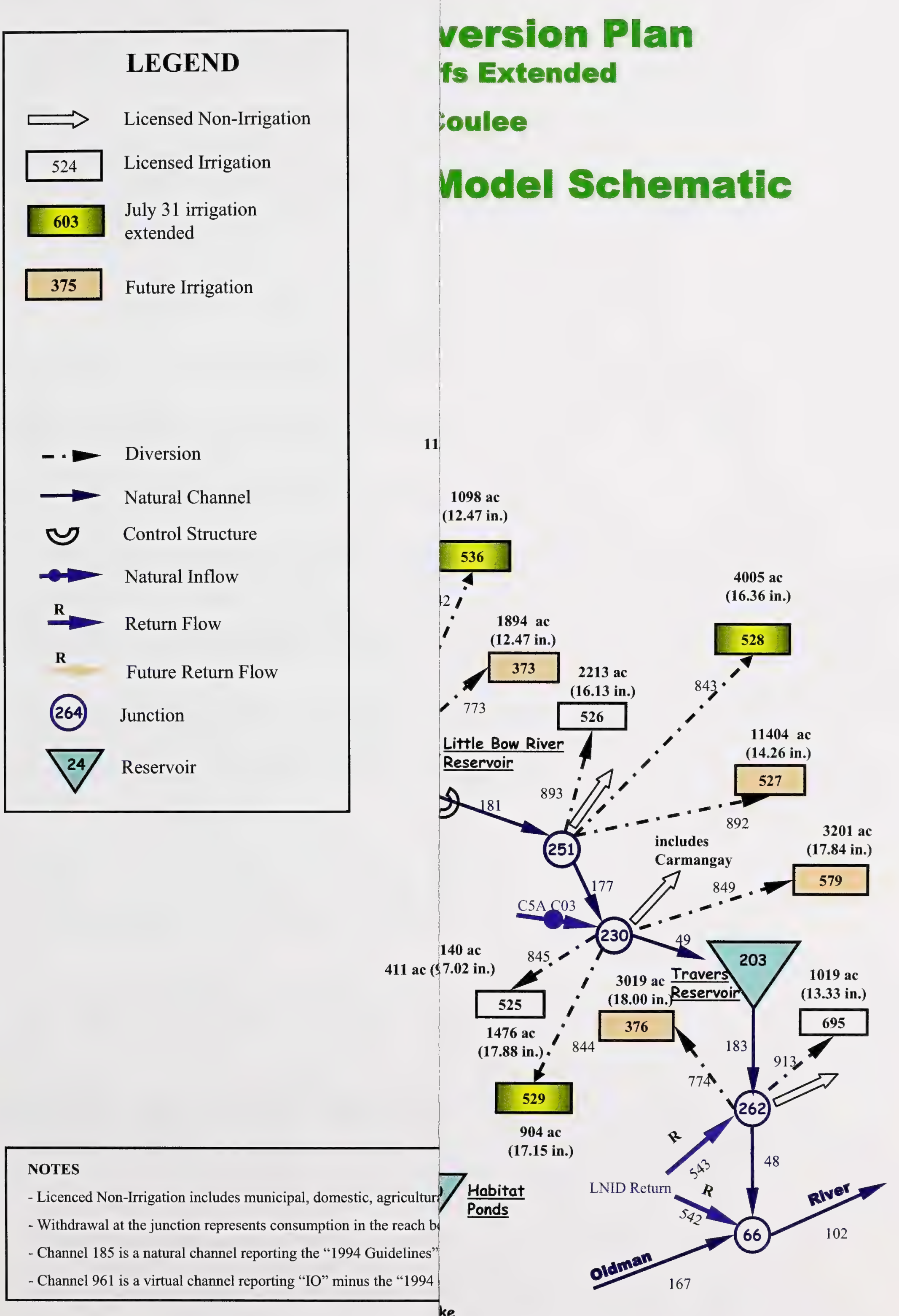
  Spills from Frank Lake could contribute to meeting consumptive and instream flow needs along the Little Bow River. More importantly, spills could result in water quality concerns along the river and in Little Bow River Reservoir. (Measures to address water quality issues are currently under consideration. The measures under consideration are unlikely to have an appreciable affect on the frequency of spill.)

  It is recommended that the water balance of Frank Lake be considered in WRMM modeling of the Highwood/Little Bow/Mosquito Creek system. This would involve including a reservoir at Frank Lake in the model configuration and a natural flow input data file. Minor uses in the watershed would have to be identified and quantified.

- The number of nodes and arcs in the model configuration defines the resolution of the model in terms of computing flows in stream reaches and performance in meeting demands. Through discussions with the Public Advisory Committee, it was recommended that the following nodes be added to the configuration to improve its resolution.

  1. Highwood River upstream of Women's Coulee Diversion
  2. Little Bow River downstream of the confluence of Frank Lake tributary
  3. Little Bow River at Old Highway 533

Figure 2 Schematic for the WRMM model si



NOTES
- Licenced Non-Irrigation includes municipal, domestic, agricultur
- Withdrawal at the junction represents consumption in the reach b
- Channel 185 is a natural channel reporting the "1994 Guidelines"
- Channel 961 is a virtual channel reporting "IO" minus the "1994

4. Little Bow River downstream of Little Bow River Reservoir
5. Mosquito Creek at Old Highway 529

The new nodes will require re-computing natural inflows for all affected reaches.

- The performance of irrigation projects in the Little Bow and Mosquito Creek Basins is one of the key factors to be considered in the development of the Highwood Diversion Plan. It was recommended that the irrigation demand be structured in three priority-level blocks at the applicable nodes.

1. Existing full-season irrigation
2. Existing July cutoff irrigation
3. Expansion irrigation

This breakdown of irrigation demand will enable reviewers of model output to determine the irrigation performance for each separate priority block.

The final model schematic is shown as Figure 2.

8. Long-term Climate Variability and Climate Change

Water management planners struggle with the age-old question of how well the historical period of stream flow and climatic conditions represent the variability in water supply and demand that can be expected in the future. Recorded data in western Canada provides a relatively short perspective on climate variability – about 100 years. From a recent review of tree rings, lake sediments and other climatic indicators, researcher Dr. David Sauchyn (1997) concluded that droughts in the 1790s and in the early and mid-19th Century were more severe than that of the 1930s or any other droughts experienced by farmers on the Canadian prairies. Dr. Sauchyn summarized his paper by stating, ".... the recent occupants of the Palliser triangle have not yet experienced the extremes of summer precipitation that occurred in the 19th and late-18th Centuries, and that could reoccur in the near future."

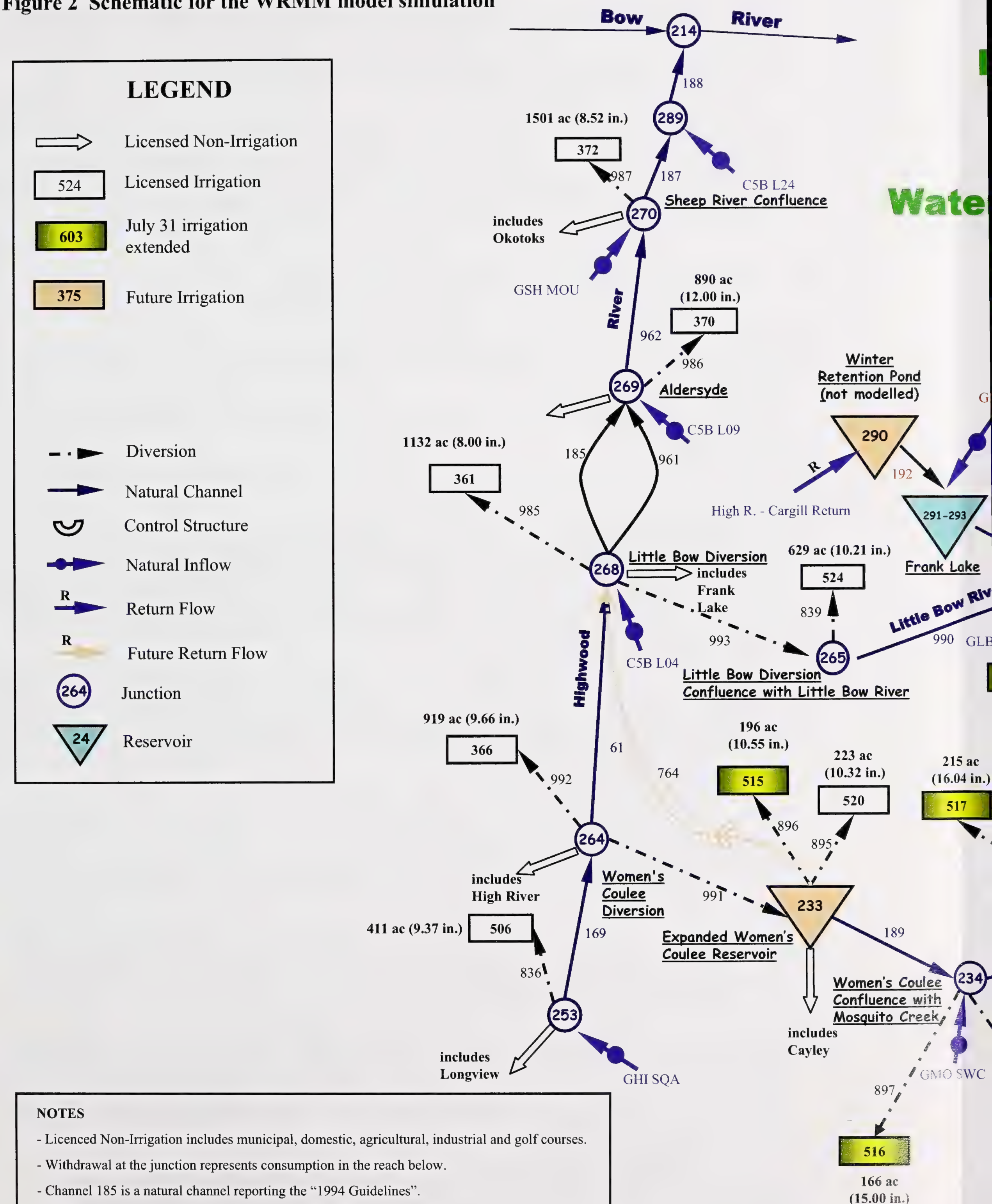
How will climate change affect the performance of the water management system in the Highwood/Little Bow/Mosquito Creek system? There is evidence that the climate on the Canadian Prairies is changing (Wheaton. 1998). There appears to be agreement that temperatures are rising and will probably continue to rise. There is less certainty about precipitation, particularly on a regional level. Several researchers have concluded that there is insufficient information to develop and analyse a credible climate change scenario at a regional level such as southern Alberta (Wilby and Karsell. 2001; Muzik. 2001; Filion. 2000; Klemes. 1990 and 1993). However, the possibility that future weather and stream flow may be different than the past must be recognised.

Simulation modelling using the 1928 to 1995 period provides a good test of performance during the major droughts of the 1930s and 1980s. However, it is important to recognise that droughts of this magnitude and even more severe are a normal and repeating characteristic of the climate of the Canadian prairies. In fact, considering the relatively favourable climatic characteristics of the 20th Century and the potential impacts of climate change, results using the recorded period could present an overly optimistic picture of the long-term water supply and demand balance.

Water managers and regulators should not wait for relative certainty on climate change before taking measures that would minimize potential negative impacts and capitalize on potential positive impacts. Measures that could be taken include the following (Gleick. 2000).

- Keep tuned in to research findings, preparedness planning, and adaptation. Establish information sharing mechanism with research organizations and leading-edge water management agencies.

Figure 2 Schematic for the WRMM model simulation



NOTES

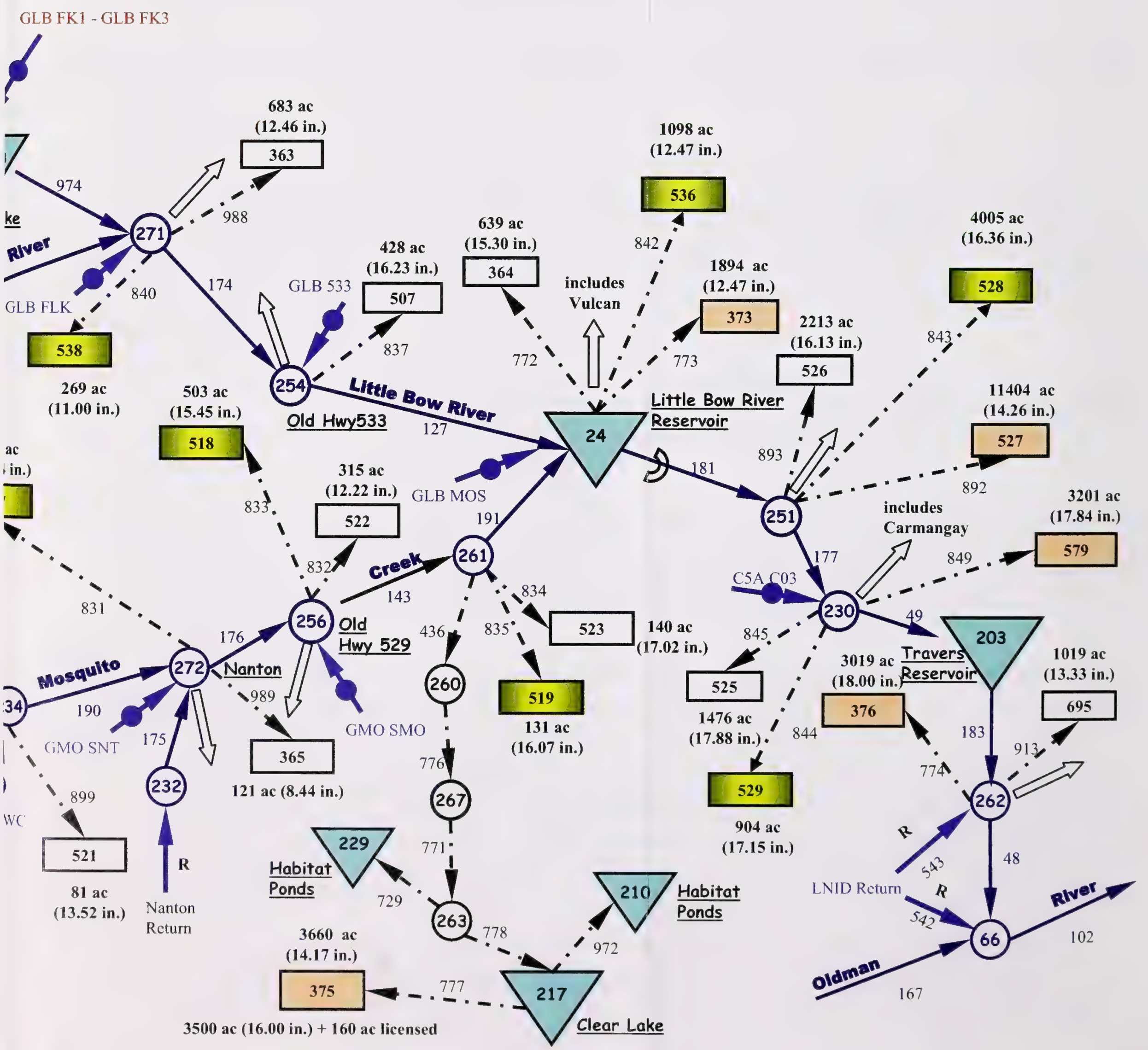
- Licenced Non-Irrigation includes municipal, domestic, agricultural, industrial and golf courses.
- Withdrawal at the junction represents consumption in the reach below.
- Channel 185 is a natural channel reporting the "1994 Guidelines".
- Channel 961 is a virtual channel reporting "IO" minus the "1994 Guidelines".

LITTLE BOW PROJECT – Diversion Plan

Licenced Demand with July Cutoffs Extended

Super Expanded Women's Coulee

er Resources Management Model Schematic



Flexibility should be designed into water management decisions, and the design and operation of infrastructure.

- Continue to improve water use efficiency and pursue demand management.
- Re-examine operating plans for existing structures. Develop contingency plans for a wide range of climate conditions and extremes.
- Consider alternate forms of supply, such as wastewater reclamation and reuse, water assignments and water transfers.
- Clarify and improve legal and administrative tools for managing and allocating water resources.
- Delay development of costly and long-lived new infrastructure, where possible, until adequate information on future climate is available.

Water managers and users in some parts of the South Saskatchewan River Basin have a history of working out ways to deal with water supply shortages. Many of the approaches required to deal with climate change and uncertainties related to future climate variations are the same as those that have been pursued and implemented to manage risks associated with historical weather variations.

Simulation modelling is a powerful analytical tool, but results of simulation modelling must interpreted recognizing its limitations.

Summary of Key Findings and Recommendations

- Recorded data reflect a water use pattern that has been changing continuously throughout the recorded period. To be useful for simulation modelling, recorded flows are adjusted to provide a more consistent database by removing the influence of some of the larger human interventions in the hydrologic regime. The current level of water use and a variety of future management options can then be superimposed on the water supply data to determine the performance of the system for various scenarios of water management.

- The natural flow database for the Highwood/Little Bow/Mosquito Creek system consists of weekly flows for the period 1928 to 1995. Development of the database involved estimating diversions and some water uses, filling in data gaps and extending records, and estimating flow at ungauged locations using well-established procedures.

- No withdrawal uses other than diversions to the Little Bow basin were accounted for in reconstructing Highwood River natural flows. Consumptive use for irrigation was considered in the Little Bow and Mosquito Creek Basins. The implications of not considering all uses in the natural flow computations for the Highwood River and Little Bow streamflow networks does not appear to be a significant issue.

- Not considering land use changes, natural spills from the Highwood River to the Little Bow basin, and channel losses (other than those inherent in the recorded flows) is not a significant issue related to modeling accuracy and interpretation.

- **It is recommended that** the model configuration be modified so that the total inflow at Carmangay does not enter the Little Bow River Reservoir, and so that the water balance of Frank Lake and spills to the Little Bow River can be determined and accounted for in the simulation runs. Several additional nodes should be added to the model configuration to provide a better definition of flows along conveyance routes.

- The full scope of climate variability, and climate change are two important water management considerations that are not addressed by simulation modelling using the recorded period of meteorological conditions. However, it is still the most popular approach for addressing complex

water management issues. Results of modelling must interpreted recognising the limitations of the input data on which the modelling is based. Where possible, flexibility should be designed into management decisions and the operation of the infrastructure to allow for mitigation of negative impacts and to take advantage of positive impacts of climate variability and climate change.

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Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Computer Simulation Modelling

Issues:
- Why is simulation modelling conducted?
- How is the Highwood/Little Bow/Mosquito Creek system represented in a computer model?
- What assumptions are inherent in the model?
- What are the limitations of the model?

Discussion:

- **Introduction**

Simulation modelling has been used extensively to analyze various water management options (scenarios) and evaluate the performance. This Fact Sheet outlines the principles and the key assumptions inherent in the simulation modelling conducted in the Highwood/Little Bow planning program. Awareness of these principles and assumptions are important to the full understanding and interpretation of results, and performance evaluations.

- **Why Model?**

Modelling is an essential analytical technique for assessing water management options and optimizing the performance of complex water management systems. The approach is based on the premise that the performance of the system over a lengthy period of recorded conditions, that includes representative flood and drought periods, provides an insight into how well the system will perform in the future. Simulation modelling assists in developing an understanding of the issues and provides a basis for a rational discussion of alternatives.

- **What are the Basic Characteristics of the Model?**

The physical configuration of streams, diversions, canals and reservoirs is represented in the model as a network of nodes and links. The nodes are locations in the physical system where there are reservoirs, stream or canal junctions, diversions or major withdrawals or inflows. Links are streams and canals. Modelling in the Highwood/Little Bow River/Mosquito Creek Basins has been conducted using a weekly time step for the 68-year period of streamflow and climatic conditions, 1928 to 1995. Input data for the model include the following:

- Weekly natural flow data at key locations in the study area.
- Consumptive water demands for various purposes, such as:
    - domestic,
    - stock water,
    - municipal,
    - industrial
    - irrigation,
    - recreation, and
    - waterfowl conservation.
- Weekly lake evaporation and precipitation data, to account for reservoir losses.

- Instream flow targets for key stream reaches.
- Canal and reservoir outlet capacities, and reservoir storage characteristics and operating rules.
- The priority system for supplying water to the various users.

Water use priorities are input to the model through a penalty point system. Deficits to high priority uses have high penalties; deficits to lower priority uses would have lower penalties. The model contains an optimization procedure that minimizes the penalties throughout the entire system in each time step (week) to establish the perfect operational solution for that time step.

The model computes water deliveries to meet demands in accord with the priorities and constraints, such as canal capacities, within the system. It also computes the resulting stream and canal flows, and reservoir levels. Subject to assumptions and modelling limitations (discussed later), the model output represents the conditions that would have existed if the management scenario had been in place during the historical period of streamflow and climatic conditions simulated.

- **What is a scenario? How are scenarios evaluated?**

A scenario is a representation of existing or future water management options, including demands, priorities, operating policies, structural facilities, and non-structural water management measures.

The performance of a scenario is assessed by analyzing output data to determine how well objectives are met, or are not met. The magnitude, frequency and duration of failure to meet objectives are common measures of performance. Water management is multi-objective. Multiple performance measures are required. Simplified tables or graphics targeted to highlight the performance in meeting specific objectives assist in evaluating the performance of one management scenario against others. Balancing the performance of multiple objectives often requires trade-offs and value judgments. Simulation modeling to explore various "what if" scenarios helps to understand the trade-offs and work toward a consensus on the best-possible alternative.

- **Modelling Assumptions**

1. Configuration

   The number of nodes and links define the resolution of the model in terms of computing flows in stream reaches and performance in meeting demands. A large number of nodes add to the complexity of the model, the extent of input data required and the difficulty in interpreting the results. The configuration of the Highwood/Little Bow/Mosquito Creek model is more detailed than most modelling exercises conducted in Alberta (elsewhere, see Scenario Schematic. AENV 2003A). Many nodes and links have been added to the model that was used for analyzing the system in the Environmental Impact Assessment (APWSS 1995) to improve its resolution.

   Local inflows and demands along stream reaches (between nodes) are totaled and input to the model at the nodes. Demands are modelled as "blocks of users" rather than as individual users. Demands are input at the upstream node; local inflow between nodes is input at the downstream node. This modelling process is somewhat conservative in that the local runoff within a reach does not contribute to meeting demands within that reach.

2. Natural Flows

   Weekly natural inflow to the study area for the period 1928 to 1995 was estimated by adjusting recorded flows to account for historical diversions and some of the larger consumptive uses (Hart 2003A). Not all uses were considered in adjusting the recorded flow due to lack of water use data for the historical period. As a result, natural flow may have been slightly higher than that used for modelling purposes, particularly in the latter part of the study period. Underestimating the natural

inflow would not have a significant impact on modelling results, but again, it represents a conservative approach.

3. Demands

Weekly irrigation demands for each irrigation block (elsewhere, see "Irrigation Block Summary". AENV 2003B) were estimated by Alberta Agriculture, Food and Rural Development based on the irrigated area, the mix of crops grown, the on-farm irrigation equipment used (efficiency), weather conditions (precipitation and evapo-transpiration), and assumed on-farm irrigation management practices. Demands were variable from year to year, being lower in cool, wet years and higher in hot, dry years.

For most irrigation blocks, crop demand exceeds the licence allocation in some years. This occurs most frequently in the Upper Little Bow and Mosquito Creek Sub-basins, where a high percentage of alfalfa, a high demand crop, is grown in the crop mix. For instance, Figure 1 indicates that in the full season block in the Mosquito Creek Sub-basin, crop demand would exceed the licence allocation in more than half of the years. Modeling assumed that irrigation applications ceased when the full licensed allocation was withdrawn from the source of supply, even if crop requirements are not met.

Weekly non-irrigation demands (municipal, industrial, livestock, etc) and return flows were estimated as average annual values at the 2001 level of development (Hart 2003B, 2003C, 2003D). Demands were assumed to be the same every year regardless of weather, market conditions, water availability, etc. Only mainstem demands are included in the model. Mainstem demands are those demands that have the potential to reduce Highwood River flows in the critical fish habitat reaches downstream of the Little Bow Diversion.

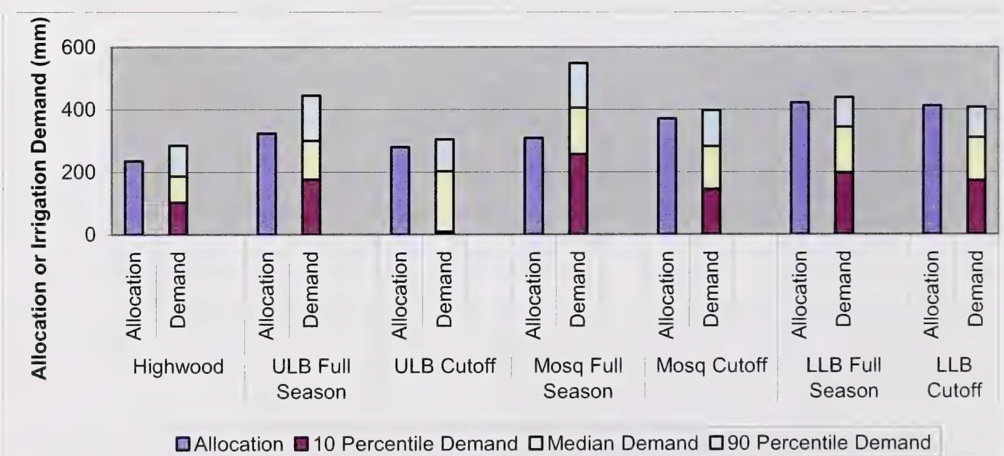

Figure 1. Relationship between crop irrigation demand and licence allocation.

4. Priorities

Water use priorities under the *Water Act* (as well as predecessor legislation) are based on the date of a completed licence application. Each licence issued in the study area has a unique priority. In water-short years, uses are cut off in order of junior to senior priority. Modelling conducted on the Highwood/Little Bow/Mosquito Creek system does not address the priority of each individual licence. Water demands of licensees are accumulated, assigned to a node, and treated as a single demand block. Assumptions on priority for demand blocks were made for modelling practicality and

convenience. Assumptions were intended to reflect reality insofar as possible. Modelling priorities and rationale are outlined in a separate document (elsewhere, see **"Scenario Construction and Priorities"**. AENV 2003C).

5. Irrigation Projects with July Cutoffs

In actual operation of the Highwood/Little Bow/Mosquito Creek system, the licensees with July cut-offs are often granted extensions to allow continued irrigation after the cut-off date when the 1994 Guidelines for Highwood River instream flows can be met, and if Little Bow and Mosquito Creek operating minimum target flows can be met. The modelled Base Case scenario assumes that the cutoffs are extended. It was felt that this best represented actual pre-Little Bow Project conditions.

Alberta Transportation filed an Interim Operating Plan with the Director in October 2002 to facilitate use of the project prior to development of the Highwood Diversion Plan. The Interim Operating Plan was based on Scenario IDP2.1, which assumes no extensions would be granted to the licences with July cut-offs. The Interim Operating Plan was modified in 2004 to include extensions to the cut-offs if sufficient water was available.

6. Inactive Irrigation Projects

There are a number of licensed irrigation projects in the study area that were not being operated in the late 1990s and early 2000s (pre-project conditions), probably for a variety of reasons. The Base Case scenario assumes that these projects are inactive, to reflect actual pre-project conditions. All IDP scenarios except IDP2.1 assume that all licensed projects are active to reflect the possibility that whatever circumstances led to not operating the projects were remedied and the licensee resumed operation, or the water allocation was transferred to a user that would operate the project.

7. System Losses

Channel losses, sometimes referred to as conveyance losses, occur as a result of channel priming (replenishing soil moisture, natural depressions, beaver dams, etc.), bank storage, seepage, evaporation and transpiration. Each of these sources of loss is discussed in a Technical Note (Hart 2003A). All components of channel losses are inherent in the recorded streamflow data on which the natural flow computations are based. Hence, at least to that extent, channel losses have been taken into account in modelling without specifying a specific demand to account for such losses. The post-project changes hydrologic regime and riparian vegetation in the Little Bow River Basin will probably alter channel losses to some degree. These changes in channel losses would be difficult to estimate. Losses are best determined by site-specific monitoring under controlled conditions, rather than theoretical computations or extrapolations from other streams.

8. Highwood River Diversion Operating Guidelines

The operational guidelines for diversions from the Highwood River to the Little Bow River and Mosquito Creek were treated as management variables in the scenarios. Diversion guidelines were modified in systematic iterations primarily in attempts to strike a balance between fish habitat on the Highwood River and irrigation performance on the Clear Lake and Lower Little Bow expansion blocks. Diversion operational guidelines considered in the modelling included:

- Pre-project 1994 Highwood Operating Guidelines (all scenarios)
- Alberta Transportation's 80% Fish Rule Curve proposed in the 1995 EIA (Scenario IDP2.1.1).
- Technical Working Group recommended Highwood IFN, or some variation of it (all scenarios except BC2.2).
- Separate drought operational guidelines triggered by low runoff forecasts and low reservoir storage levels (Scenarios IDP2.5.2.9.8 and IDP2.5.2.9.8C).

A discussion of Instream Needs, Instream Objectives, Water Conservation Objectives and variations in operational guidelines considered in the scenarios is presented in the Fact Sheet, **"Highwood River Aquatic Protection and Diversion Rules"** (Hart 2003E).

- **Model Limitations**

  1. Operational Gap: Modelling vs Real Time

  The model operates on a weekly time step. It assumes perfect knowledge of supply and demand for each time step – in other words, perfect one-week forecasting. In actual operation, the operators do not have perfect forecasting of supply or demand. Attempting to match water deliveries to water demands in the face of uncertainty, operators naturally lean toward erring on the side of caution by delivering more water than might be required, to avoid pump cavitations, shut downs, lost revenues, and much aggravation for the operator and user alike. Because of perfect forecasting in the model versus the uncertainties of real-time operations, model output for scenarios attempting to replicate existing conditions may be different than recorded system performance. The "operational gap" is common to all scenarios. Scenario performance is best evaluated in a comparative manner, comparing the performance of one scenario against that of another. The relative success or failure of model output should approximate the relative success or failure in real-time operations.

  2. Historical Climate Variability

  Simulation modelling has been conducted over the historical period of weather and streamflow conditions from 1928 to 1995. How well does the 68-year period of recorded conditions represent the variability in water supply and demand that can be expected in the future? Studies of tree rings, lake sediments and other climatic indicators on the Canadian prairies have shed some light on the climate of past centuries (Sauchyn 1997; Case et al 2003). Researchers have concluded that streamflows were relatively high on the Canadian Prairies during the 20th Century compared with earlier centuries. Sauchon concludes that, ".... the recent occupants of the Palliser triangle have not yet experienced the extremes of summer precipitation that occurred in the 19th and late-18th Centuries, and that could reoccur in the near future." This conclusion suggests that modelling results using the 1928 to 1995 recorded period could present an overly optimistic picture of long-term water supply and demand.

  3. Future Climate Variability

  How will climate change affect the performance of the water management system in the South Saskatchewan River Basin? Was the 2000/2001 drought in southern Alberta a harbinger of what can be expected in the future? Or was it an outlier in the recorded period with a very low probability of reoccurrence, much like the 1995 Oldman flood was on the other side of the scale? No one can say for certain. There is evidence that the climate on the Canadian Prairies is changing (Wheaton. 1998). There appears to be agreement that temperatures are rising and will probably continue to rise. There is less certainty about precipitation, particularly on a regional level. Existing Global Circulation Models (GCMs) that are used to predict impacts of climate change have data points at 300 to 500 km intervals. Because precipitation is so highly variable, much higher resolutions are required to determine regional precipitation and its impacts on water resources. Several researchers have concluded that, at present, there is insufficient information to develop and analyse a credible water resource climate change scenario at a regional level (Wilby and Karsell. 2001; Muzik. 2001; Filion. 2001). However, it must be recognized that weather, streamflow and agricultural growing conditions may be different in the future than they have been in the past.

Summary of Key Findings

- The Highwood/Little Bow/Mosquito Creek water management system is relatively compact, but a complex system with may challenges. Simulation modelling is the only method by which various

management options can be explored and the inter-relationships among management variables can be defined.

- Simulation modelling is a powerful analytical tool, but output from simulation modelling must be interpreted recognizing its assumptions and limitations. In particular, there are uncertainties related to how well simulation modelling based on the 68-year period 1928 to 1995 represents climatic variations of the past and of the future.

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Scenario Construction & Priorities

What are the purposes of the Base Case (BC) and Interim Diversion Plan (IDP) scenarios?

Base Case Scenario

Purpose:

- Depicts pre-Little Bow Project water management conditions
- Serve as a basis for comparison for diversion plan scenarios

Data used:

- Based on variable irrigation demand
- Based on average annual non-irrigation demand
- Excludes inactive irrigation projects

Diversion Plan Scenarios

Purpose:

- Depicts water management options ("what if" scenarios) with the Little Bow Project in operation (the Little Bow project includes Clear Lake)
- Priorities stem from direction provided by the Joint Review Panel 1998 Decision Report

Data used:

- Incorporates Base Case data, irrigation expansion, and Highwood Instream Objective (IO) rules.

What modeling priorities are used in the Base Cases and the Interim Diversion Plans?
(Note: See Fact Sheet: *Computer Simulation Modeling* for an explanation of the use of modeling priorities)

Base Case Priorities
(*some exceptions may apply)

1. Existing Highwood, Little Bow and Mosquito Creek Non-Irrigation
2. Existing Highwood Irrigation
3. 1994 Highwood Operating Guidelines
4. Existing Little Bow and Mosquito Creek Irrigation without cut-off dates
5. Existing Little Bow and Mosquito Creek Irrigation with July cut-off dates
6. Operating Minimum Flows: Little Bow (20 cfs year-round) and Mosquito Creek (10 cfs non-winter only)
7. Inflow to Travers Reservoir (20 cfs year-round)

Interim Diversion Plan Priorities
(*some exceptions may apply)

Priorities 1-7 of the Base Case and:

8. Existing Little Bow Irrigation off and below the Little Bow Reservoir with July cut-off dates removed
9. Technical Working Group recommended Highwood River IFN or variation thereof
10. Environmental Flows: Upper Little Bow (40 cfs non-winter only) and Mosquito Creek upstream of Clear Lake Diversion (30 cfs non-winter only)
11. Clear Lake irrigation expansion (3500 acres plus existing 160 acres licensed)
12. Little Bow irrigation expansion (16,500 acres)
13. Clear Lake Wetlands
14. Clear Lake
15. Little Bow Reservoir

Modeling Priorities

Rationale

Modeled priorities stem from the Joint Review Panel 1998 Decision Report. In this Report, the Panel indicated that the objectives of the revised diversion plan should be to ensure that:

- the science-based IFN is observed in the Highwood
- existing licence commitments are upheld
- adequate conveyance flows are maintained in both the upper Little Bow River (30-40 cfs) and lower Mosquito Creek (20-30 cfs)
- known demands can be met, and
- consideration is given for reserving water, if possible, for future requirements that are unknown at this time.

Priorities (Type of Demand) *Some exceptions may apply

1. **Existing Highwood, Little Bow and Mosquito Creek Non-Irrigation**
   Rationale:
   - Existing licence commitments. Includes municipal and industrial demands. Generally, these demands are small relative to irrigation demands.
   - Individual licence priorities are highly variable. For modeling purposes, non-irrigation demands are lumped together and modeled as a high priority

2. **Existing Highwood Irrigation**
   Rationale:
   - Existing licence commitments.
   - These are senior existing licences that represent a major consumptive use. They are not subject to any instream objectives.

3. **1994 Highwood Operating Guidelines (January 1 to December 31)**
   Rationale:
   - AENV uses these guidelines (which include temperature and dissolved oxygen criteria) for the operation of the existing Little Bow and Mosquito Creek diversions to protect Highwood flows.

4. **Existing Little Bow & Mosquito Creek Irrigation**
   Rationale:
   - Existing licence commitments.
   - Current operation: these demands are subject to the 1994 Highwood Operating Guidelines.
   - These are senior licences that represent a major consumptive use.

5. **Existing Upper Little Bow & Mosquito Creek Irrigation with cut-off dates**
   Rationale:
   - Current operation: these demands are subject to the 1994 Highwood Operating Guidelines.
   - These are licences with cut-off dates (the July 25 cut-off licences are grouped together with July 31 cut-off licences for modeling convenience).

- These licences are junior to the full-season licences.
- In practice, extensions beyond July 31 have been granted in the past provided water is available. Extensions are assumed in the modeling (priority of extension is the same as the licence priority [modeled priority #5], with the exception of one scenario that was run using a split priority: priority #5 prior to July 31, priority # 10A after July 31).

6. **Operating Minimum (Target) Flows: upper Little Bow (20 cfs year round) & Mosquito Creek (10 cfs non-winter only)**
   Rationale:
   - Current operation: AENV tries to maintain these minimum flows for the entire reach to meet existing demands.
   - The minimum flows are modeled for the entire reach, but under stress conditions (as identified in the 1994 guidelines) irrigation withdrawal may encroach on the operating minimum.
   - Operating minimums are adjusted in the Drought Operation Scenario. In drought years, Mosquito Creek (downstream of the Clear Lake Diversion) is 30 cfs from May 1-July 15; the upper Little Bow (upstream of the Little Bow Reservoir) is 75 cfs from May 1-July15 to increase storage in Twin Valley and Clear Lake Reservoirs during drought years.

7. **Inflow to Travers Reservoir (20 cfs year round)**
   Rationale:
   - Current operation: while not a legal requirement, AENV tries to maintain an average of 20 cfs inflow to Travers Reservoir after upstream demands are met to meet needs along the Little Bow River downstream of Travers Reservoir. During winter, the 20 cfs is from the Little Bow River, during non-winter Mosquito Creek and Little Bow River contribute to the flow in the lower Little Bow.
   - More than 20 cfs inflow to Travers is possible during spring runoff. The stored Little Bow water in Travers is eventually used to meet licenced demands on the Little Bow River downstream of Travers Reservoir.

8. **Existing Little Bow Irrigation off and below Little Bow Reservoir with July 31 cut-off dates removed**
   Rationale:
   - This is based on the idea that since shortages will have been dealt with once the reservoir is in place, cut-off dates will no longer be required on licences downstream of the reservoir.
   - The modeling assumes same licence priorities (with the exception of one scenario that was run using a split priority: priority #8 prior to July 31, priority # 10A after July 31), but subject to minimum flow downstream of Little Bow Reservoir to Travers Reservoir (20cfs).

9. **Highwood River IFN (Technical Working Group-Recommended IFN) or a variation thereof (i.e., Instream Objective)**
   Rationale:
   - The Highwood River IFN (or variation thereof, depending on the scenario) precedes the Little Bow River and Mosquito Creek environmental flows (priority #10) because the IFN or IO is used to determine how much water is to remain in the Highwood (conversely, how much water can be diverted to the Little Bow River and Mosquito Creek)

10. Upper Little Bow (40 cfs non-winter only) & Mosquito Creek upstream of Clear Lake Diversion (30 cfs non-winter only) Environmental Flows

Rationale:

- While not a legal requirement (though they could be a future IO), AENV tries to meet these target flows to enhance water quality etc. after the Highwood IFN is met.
- The Mosquito Creek flow of 30 cfs is maintained to the Clear Lake diversion only.
- These environmental flows may change depending on the water quality requirements as determined by, e.g., Frank Lake designs.

11. Clear Lake irrigation expansion (3500 new acres plus 160 existing acres licensed: total: 3660 licenced acres)

Rationale:

- Licences to be initially supplied by Clear Lake and subsequently supplied by water diverted from the Highwood River (during spring flow) after prior demands (1-10) are met including the Highwood IFN.

12. Little Bow irrigation expansion (16,500 acres);

Rationale:

- Licences to be supplied from storage in the Little Bow Reservoir and by water diverted from the Highwood River after prior demands are met including Highwood IO.

13. Clear Lake Wetlands

Rationale:

- While the filling of Clear Lake wetlands and Clear Lake falls under one licence, these demands are modeled separately to avoid the problem of the model always filling Clear Lake to the detriment of the wetlands.
- There are guidelines that specify a window for filling the wetlands to avoid raising the water level during nesting season.

14. Clear Lake

Rationale:

- Clear Lake has smaller storage than the Little Bow Reservoir and supports licences with higher priority than Little Bow expansion licences. Supplies existing demands and irrigation expansion off of Clear Lake. Licence to fill Clear Lake is subject to prior demands being met, including Highwood IFN or IO.
- Clear Lake and Little Bow Reservoir priorities (14-15) are low on the list because all other demands must be able to draw on storage (otherwise, the model would try to keep these storages full at the expense of meeting user demands). As well, the Little Bow Project was not intended to adversely affect existing upstream and downstream licensees or the Highwood IFN or IO.

15. Little Bow Reservoir

Rationale:

- Larger Storage. Supplies existing demands and irrigation expansion off and downstream of the Little Bow Reservoir. License to fill Little Bow Reservoir is subject to prior demands being met, including Highwood IFN or IO.

Andrea Czarnecki
Alberta Environment
September 2003

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Drought Period Operation Procedures

Issues:

- Can drought operation rules that differ from normal operations be developed and implemented in real time operations for the Highwood/Little Bow system?
- Can such rules be modelled?
- Will such rules improve irrigation performance without significantly encroaching on Highwood River fish habitat?

Discussion:

- **Introduction**

The Public Advisory Committee's Modelling Focus Group worked closely with Alberta Environment and Alberta Transportation staff to develop and evaluate scenarios that would provide satisfactory irrigation performance in the Clear Lake and Lower Little Bow irrigation expansion blocks without severely impacting on Highwood River fishery habitat. Several scenarios were analyzed and evaluated. Those deemed to have most promise were reviewed with irrigators at a meeting in Champion on April 11, 2003. Irrigators were concerned about the magnitude and frequency of deficits, and particularly the large deficits in back-to-back years. They suggested developing and testing separate drought operation rules that could be implemented to avoid back-to-back deficits. Deficits in the second and third years of drought would be shared between irrigators and Highwood fish habitat.

Drought operational rules, primarily based on forecasted streamflow, are used in real-time operations of water management infrastructure. Such rules have been tested using AENV's WRMM model for time periods varying from a season to a couple of years. Variable operating rules have never been used in WRMM modelling conducted for long-term water management planning purposes where an extended historical period is simulated (in our case the 68-year period 1928 to 1995). The make-up of the WRMM model is not conducive to testing variable operating plans. Nonetheless, AENV modellers took up the challenge and developed a procedure to test variable operating plans.

The procedure required three steps. Firstly, a "trigger" rule was required to define conditions when the drought operational plan would come into effect. Secondly, the deviations from the "normal" operation plan that would result in improved irrigation performance while minimizing encroachment on Highwood River fish habitat had to be defined. Thirdly, a procedure for running the model with variable operating rules had to be developed.

- **The Trigger Rule**

The trigger rule must be developed using data that would be available or could be estimated in real-time operations. Performance success is primarily dependent on Highwood River streamflow during the summer period and the amount of pre-runoff storage in Clear Lake and Little Bow River Reservoirs. In real-time operations, Highwood River March 1 to September 30 flow volumes are routinely estimated by AENV's River Forecast Centre . The forecasts are based upon:

- monitored basin snow pack information,
- prior precipitation and basin moisture and runoff conditions,
- general weather trends, and
- assumptions regarding summer precipitation (e.g.: lower quartile, median, upper quartile).

From analyses of scenarios that did not incorporate drought operational rules, it was found that back-to-back deficits greater than 100 mm had some common runoff and storage pre-conditions (Table 1). These pre-conditions became the trigger rules. Separate rules were developed for the Women's Coulee Diversion and the Little Bow Diversion.

Table 1 Trigger rules for drought period operation procedures.

Diversion	Implement Drought Operation Rules If:			
	Mar 1 to Sept 30 Volume Forecast as of May 1 is:		Reservoir Level on May 1 is: Clear Lake Res.	Little Bow River Res.
Women's Coulee	< 300,000 dam^3 **OR** < 400,000 dam^3	**AND**	< 965.0 m	
Little Bow	< 400,000 dam^3	**AND**		< 957.0 m

- **The Drought Operation Rules**

The objective of the drought operation procedures is to modify the normal operation plan, in years when conditions indicate a potential for irrigation deficits greater than 100 mm, by increasing inflow to Clear Lake and Little Bow River Reservoirs by amounts sufficient to reduce deficits in the expansion blocks to less than 100 mm. Increasing diversions during the high runoff period by modifying the operational flow targets would build storage at Clear Lake and/or Little Bow River Reservoir so the demands could be better met by releases from storage during the low runoff period. The impact on fish habitat would occur only in the drought years and would be limited to the, normally, high flow period, May 1 to early July.

Several trials were made by incrementally modifying the minimum operational flow targets for Mosquito Creek and the Upper Little Bow River before arriving at the magnitude and period of adjustments that would satisfy the objectives. Table 2 shows the operational flow targets under the normal operation plan and under the drought operation procedure for Scenario IDP8CS1. All other aspects of the operation remain the same. The objectives were met by modifying the minimum operational flow target for Mosquito Creek downstream of the Clear Lake Diversion to 30 cfs from 10 cfs, and for the Upper Little Bow upstream of the Little Bow River Reservoir to 75 cfs from 30 cfs. Both modifications were made for the period May 1 to July 15.

Minimum operational flow targets are base flows required to meet conveyance losses, keep the stream live to meet needs for traditional agricultural uses and other non-irrigation uses, and assist in maintaining water quality. They have a higher priority than the new Highwood River instream objectives (or some variation thereof) recommended by the IFN Technical Working Group.

Table 2 Modification of the normal operating plan for drought periods (Scenario IDP8CS1).

	Mosquito Cr D/S Clear L. Diversion Minimum Operating Flow Target				Upper L. Bow R. U/S L. Bow R. Reservoir Minimum Operating Flow Target			
	Apr 1 – Apr 30	May 1 – Jul 15*	Jul 16 – Sept 30	Oct 1 – Mar 31	Apr 1 – Apr 30	May 1 – Jul 15	Jul 16 – Sept 30	Oct 1 – Mar 31
Normal Operation Plan	10 cfs	10 cfs	10 cfs	10 cfs	20 cfs	30 cfs	30 cfs	20 cfs
Drought Operation Rule	10 cfs	30 cfs	10 cfs	10 cfs	20 cfs	75 cfs	30 cfs	20 cfs

* **Increased May 1 to July 15 minimum operating flow targets** are required to increase storage in Twin Valley and Clear Lake Reservoirs during drought years.

- **Running the WRMM with Drought Operation Rules**

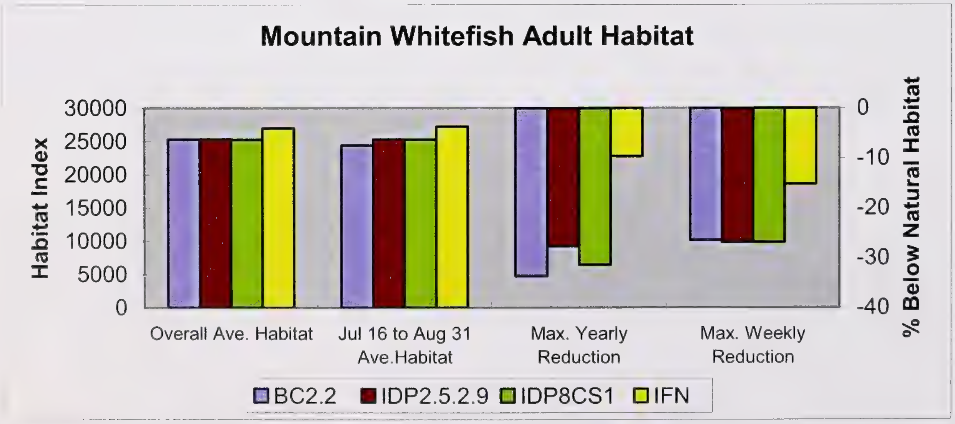
Because variable operating rules cannot be accommodated in the WRMM model, the model had to be stopped each time the operational rules changed and restarted with modified rules. This required up to 18 individual WRMM runs to assemble a single scenario where trigger rules were applied. The trigger rules called for drought operations for the Women's Coulee Diversion in 10 years, with one false alarm (in 1989 conditions existed for deficits greater than 100 mm but summer rains provided relief). Drought operations for the Little Bow Diversion were called for in four years, with one false alarm (1937).

Units -- In Table 2 flow values are given in familiar imperial units. For conversion to metric units,

1.0 cfs = 0.0283 m^3/s
1.0 m^3/s = 35.3 cfs.

- **Evaluation of Performance**

Incorporating the drought operation rules in a simulation modelling run accomplished the objective of reducing irrigation deficits and eliminating back-to-back deficits greater than 100 mm in the Clear Lake and Lower Little Bow expansion blocks. The impact on Highwood River fishery habitat was minimal (see comparison between IDP2.5.2.9 and IDP8CS1 in figure below). Data demonstrating the performance of the drought scenario are provided in the document, "Irrigation Performance and Highwood Fish Habitat".



Comparative fish habitat performance for Base Case (BC2.2), Interim Diversion Plan with no forecasting and drought operation (IDP2.5.2.9), Interim Diversion Plan with forecasting and drought operation (IDP8CS1), and the technical IFN recommended by the IFN Task Force.

Summary of Key Findings

- Drought operation rules that differ from normal operations can be defined and implemented in real time operations for the Highwood/Little Bow system.

- The WRMM is not set up to model variable operation rules. Nonetheless, drought rules were modelled for the Highwood/Little Bow system by stopping the model each time the operational rules changed and restarting with modified rules.

- Incorporating drought operating rules in a simulation modelling run accomplished the objective of reducing irrigation deficits and eliminating back-to-back deficits greater than 100 mm in the Clear Lake and Lower Little Bow expansion blocks. The impact on Highwood River fishery habitat was minimal.

References:

Hart J. R. and R. Middleton 2003. Irrigation Performance and Highwood Fish Habitat. Environmental Management, Southern Region, AENV. Calgary, AB.

J. R. Hart, P.Eng.
HART Water
Management Consulting
October 2003

Review of Additional Storage

Background

The initial application for the Little Bow Project included an option to expand the Women's Coulee Reservoir from a storage capacity of 360 dam^3 to 6380 dam^3. The purpose of the additional storage was primarily to store water in the spring and release it during the summer to protect fish habitat by offsetting summer diversions to the Little Bow River. Although presented as an option, it was not supported in the application. Analysis had made it clear that the habitat benefits would be minimal.

During review of the application, the Joint Review Panel asked that an option of further expansion of Women's Coulee Reservoir be considered. This became known as the Super Expanded Women's Coulee option. The Panel wanted to know how large a reservoir could be built at that location without affecting Women's Buffalo Jump. It was determined that a reservoir with a capacity of 16 200 dam^3 could be built at that location. Using the rules within the Diversion Plan of the day, it was determined that such a reservoir could provide a reasonably reliable supply of water to offset deficits to consumptive demand and augment instream flows. The estimated cost of the project was $15.7 million, not including environmental mitigation. The October 1997 "Response to Joint review Panel Report of the Pre-Hearing Conference" concluded:

With a reservoir of this size in place it would be possible to

1. *eliminate all deficits to current and future irrigation,*
2. *meet 100% Fish Rule Curve values at all times,*
3. *provide a 0.28 m^3/sec (10 cfs) conveyance flow down the Little Bow River and Mosquito Creek, and*
4. *significantly augment flows in the Little Bow River and Mosquito Creek much of the time but not to reliably supply 0.85 m^3/sec (30 cfs) to the streams.*

Further evaluation of this expansion option was undertaken in 2001 as part of a comparative site assessment required by NRCB Board Order 6 arising from the Joint Panel Decision Report. On the basis of more extensive and rigorous data gathering and analysis, this study determined that the cost of a 17,300 dam^3 reservoir would be on the order of $37.9 million including estimates for land acquisition and environmental mitigation. It determined that a reservoir of this size at that location with an inlet canal capacity of 3.4 m^3/sec could store and supply an average of 14,700 dam^3 per year. However, there would still be an average deficit to the instream (Fish Rule Curve requirements as detailed in the Environmental Impact Assessment [EIA] documents submitted with the application) and consumptive needs, as defined at the time, of over 6000 dam^3 per year. Modelling at the time indicated that there would be adequate water supply in the spring to fill the storage virtually every year, but also identified demands that would also empty it virtually every year.

Modelling and assessment undertaken as part of the Highwood Water Management Plan now indicate that expanding Women's Coulee Reservoir, increasing the capacity of its inlet canal, and providing a return canal back to the Highwood River would not significantly assist in water management in the basin. Some of the changes in the conclusions are related to improvements in modelling that have occurred over time resulting in a more accurate assessment. However, the main reasons relate to a revised approach to determining instream flow needs. The Technical Working Group established to revise the IFN made changes to the curves used to relate flows to habitat quantity and modified the approach to defining IFN as described in the group's report.

Diversion Limitations

As discussed above, earlier work had determined that there was adequate flow in the Highwood River to supply an additional 17,000 dam^3 of storage on a relatively reliable basis. This determination was based on the instream flow needs study that was submitted as part of the project application and formed the basis of the original Diversion Plan. However, the Joint Review Panel required under Natural Resources Conservation Board Order 9601-01 instructed Alberta Transportation to "revise the IFN analysis used in the Application to reflect current fisheries management objectives for the Highwood River and to include instream flow needs based on the most recent information regarding the River, and current scientific assessment procedures." Based on the testimony of expert witnesses during the hearing, the Panel expected that this would result in significant changes only during the summer low flow period. Consequently the Panel approved the original Diversion Plan as submitted for all but that period.

In the intervening years, however, the Government of Alberta has radically changed the approach taken to establishing instream flow needs. The newer approach attempts to better mimic the natural variability of the stream both within years and between years. As a result, the revised instream flow needs assessment flow recommendation is based on a proportion of the natural flow, which restricts the ability to divert water even during relatively high flow periods.

The change in instream objectives has a significant effect on the ability to divert water from the Highwood River to the Little Bow River basin. The combined capacity of the Women's Coulee Diversion and the expanded Little Bow Diversion is 10.2 m^3/sec (360 cfs). The Fish Rule Curve approach presented in the EIA documents would allow diversion at that full capacity to occur at any time when the Highwood River flows were 24.4 m^3/sec (860 cfs) and in some weeks at even lower flows. The recommendation of the Technical Working Group would not allow full diversion to occur until flows reached 68.0 m^3/sec (2400 cfs). Instream Object Rule 3 allows more water to be diverted at flows where diversions have relatively little effect on fish habitat and permits full diversion at flows of 31.1 m^3/sec (1100 cfs).

Figure A-1 shows the difference between the average weekly water demands of Instream Objective Rule 3 (a derivative of the Technical Working Group's recommendation) compared to the Fish Rule Curve recommended in the original Instream Flow Needs report). It demonstrates how the new approach attempts to protect the normal distribution of flows throughout the year, preserving the spring freshet.

Figure A-2 shows the difference in demands between the same two operating rules for the normal operating season on an annual basis. Here it can be seen how the demand under Instream Objective Rule 3 is not only consistently much greater but also varies considerably more, better mirroring the natural year to year variation.

Water Availability for Storage

Figure A-3 shows the volume of water that would be available for storage on an annual basis without impinging on the Technical Working Group's flow recommendation. There are years in which there are in excess of 60 000 dam^3 available, but also many, including several in a row in which little or no water would be available.

Figure A-4 shows what the situation would be using Instream Objective Rule 3 instead of Technical Working Group recommended values. Again, although there is more water available for storage, there are still many years in which little or no water is available.

Carryover Storage

Lack of water available for storage in a given year is not a significant concern if enough water can be stored in wet years to meet demands in dry year. Figures A-3 and A-4 clearly show that, even with a relatively restrictive instream objective there are years in which substantial volumes of water could be

stored if sufficient diversion and storage capacity were available. The question becomes then one of how large a diversion capacity would be required and how much storage in order to provide the necessary carryover.

Figure A-5 shows the maximum and minimum annual water level elevations for the Super Expanded Women's Coulee as modelled. It shows that there are many years in which the reservoir does not fill and that it is drained below the minimum operating level for the north dam almost every year. This indicates a mismatch between the demands placed on the reservoir and the reliability of water supply. Figures A-3 and A-4 indicate that it is not the size of the diversion canal, but the limitations imposed by the Instream Objective that are generally preventing reservoir filling.

Figure A-6 shows the volume of water that Super Expanded Women's Coulee, as modelled, returned to the Highwood River annually to try to meet instream demands. Analysis has shown that in virtually all years there are still deficits to the instream objective. The years in which there are no returns to the Highwood River are years in which there was no water available to return. The reservoir modelled is the largest that could be constructed at the site and modelling has shown that it cannot be filled reliably at that size. With the diversion restrictions contemplated, it is clear that the reservoir could not meet the needs the Panel anticipated it would. As the principle intention was to meet instream objectives, there is no rationale for further compromise in order to increase water available for storage.

The effects of this supply variability are shown in the fish habitat analysis data. Figures 7 and 8 show the mountain whitefish adult overall average habitat and habitat for the summer low flow period respectively. In both cases there is a modest increase in habitat attributable to the Super Expanded Women's Coulee storage by comparison to the comparable scenario without the additional storage. Figure 9 shows the maximum yearly reduction in habitat from natural and is an indication of habitat availability in low flow years. It shows that there is virtually no benefit from the added storage at these times. Figure 10 provides further clarification of this situation. It graphs annual habitat availability for each of the years modelled. It demonstrates a minor increase in habitat in average and higher flow years, but little or no difference in low flow years. Since these years are the ones in which habitat is most likely to be limiting to fish populations, the added storage appears to have very little value for improving fish habitat.

Storage for Other Purposes

Public Advisory Committee members have asked if there would be a volume of water that a Super Expanded Women's Coulee could reliably supply, considering other high value uses for the water. Certainly there is. Detailed modelling has not been conducted to determine the exact volume but preliminary analysis suggests that it would be on the order of 3000 dam^3 per year. Using the cost estimate of \$37.9 million, that would result in a cost of approximately \$12,500/dam^3 supplied. This is a high cost even for municipal or industrial water supply.

It might be noted that the less demand placed on the reservoir annually, the lower the average drawdown, reducing concerns about aesthetics and mud flats. There could, however, be water quality concerns related to the longer residence time of water in the reservoir.

Ron Middleton
Alberta Infrastructure and Transportation
March 9, 2004

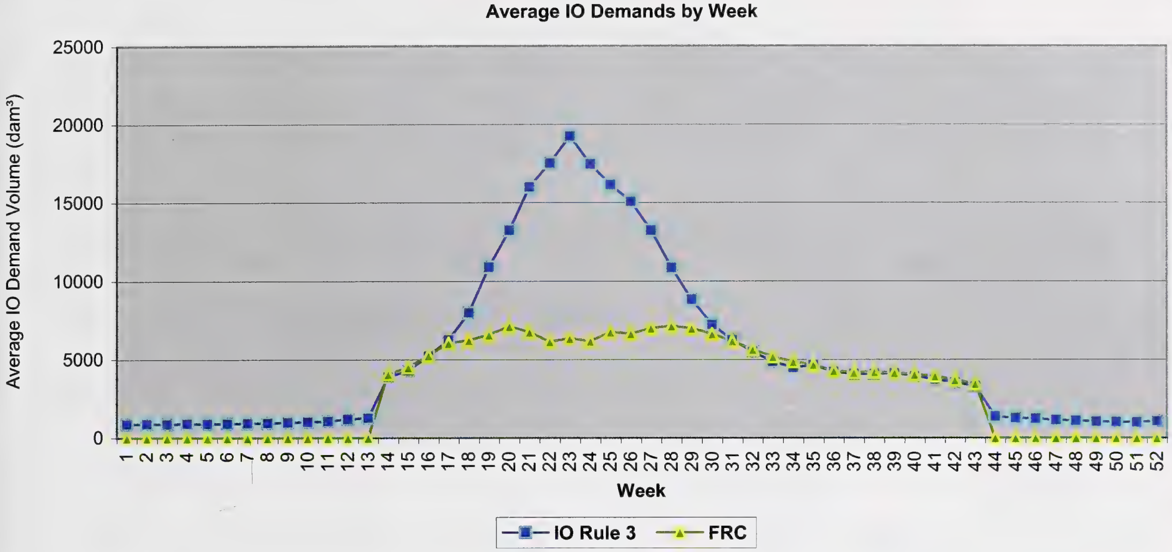


Figure 1 Average weekly instream requirements – Rule 3 versus Fish Rule Curve.

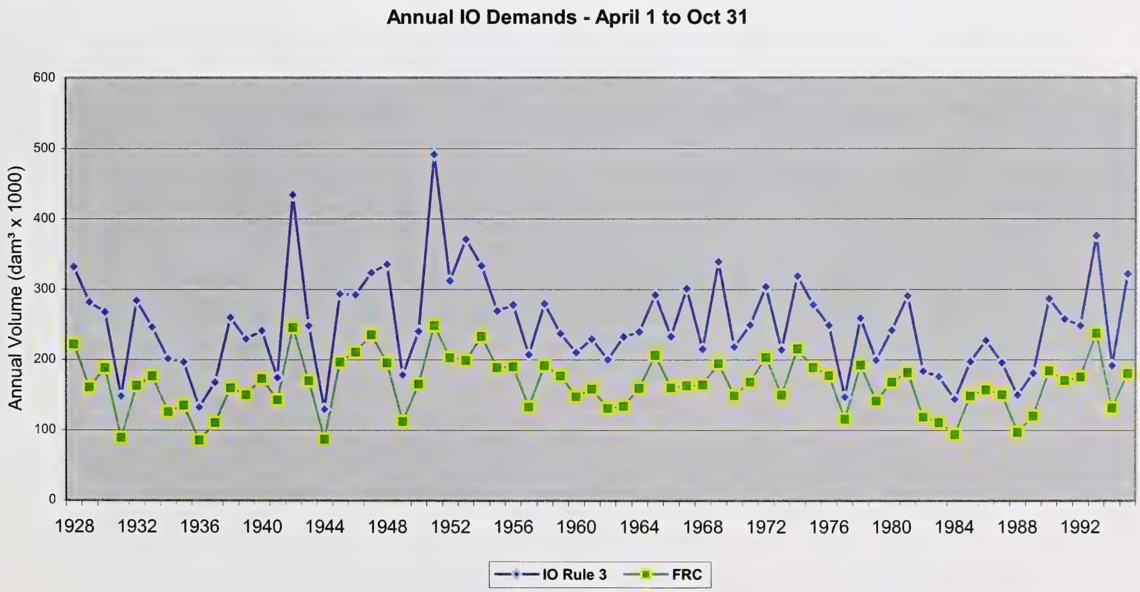


Figure 2 Annual instream requirements – Rule 3 versus Fish Rule Curve.

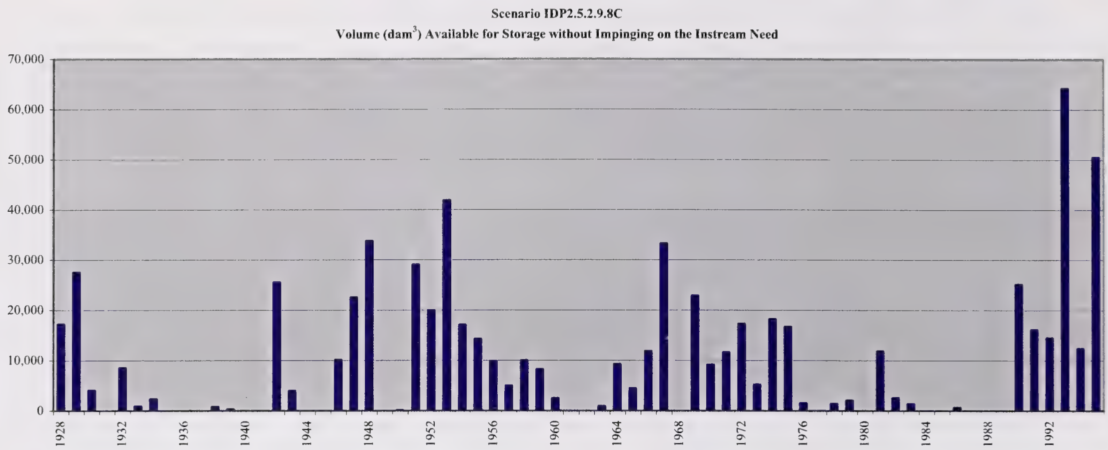


Figure 3 Volume of water available for storage (dam^3) without impinging on the recommended technical IFN.

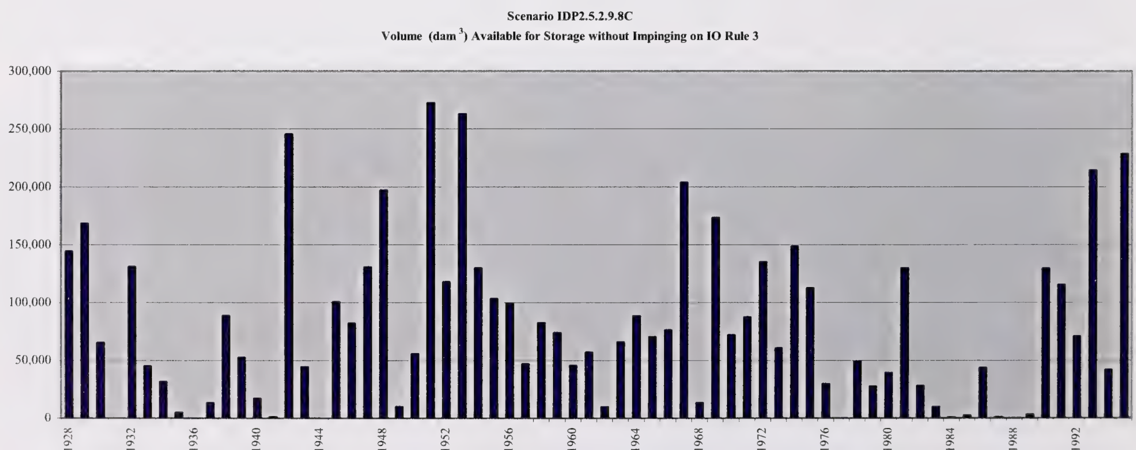


Figure 4 Volume of water available for storage (dam^3) without impinging on IO Rule 3.

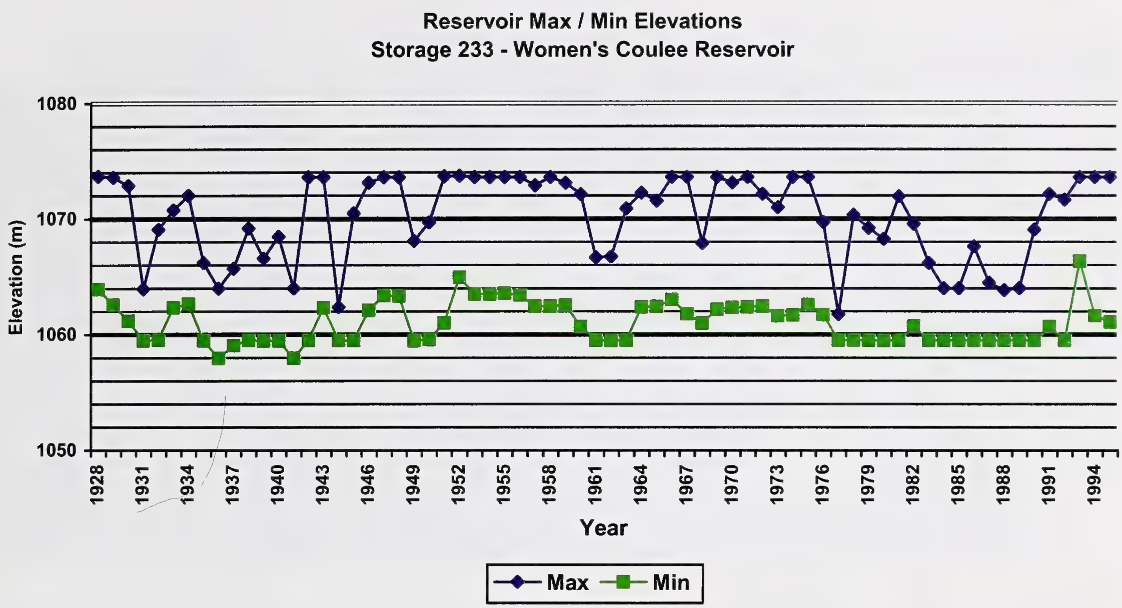


Figure 5. Maximum and minimum water levels for Super Expanded Women's Coulee Reservoir.

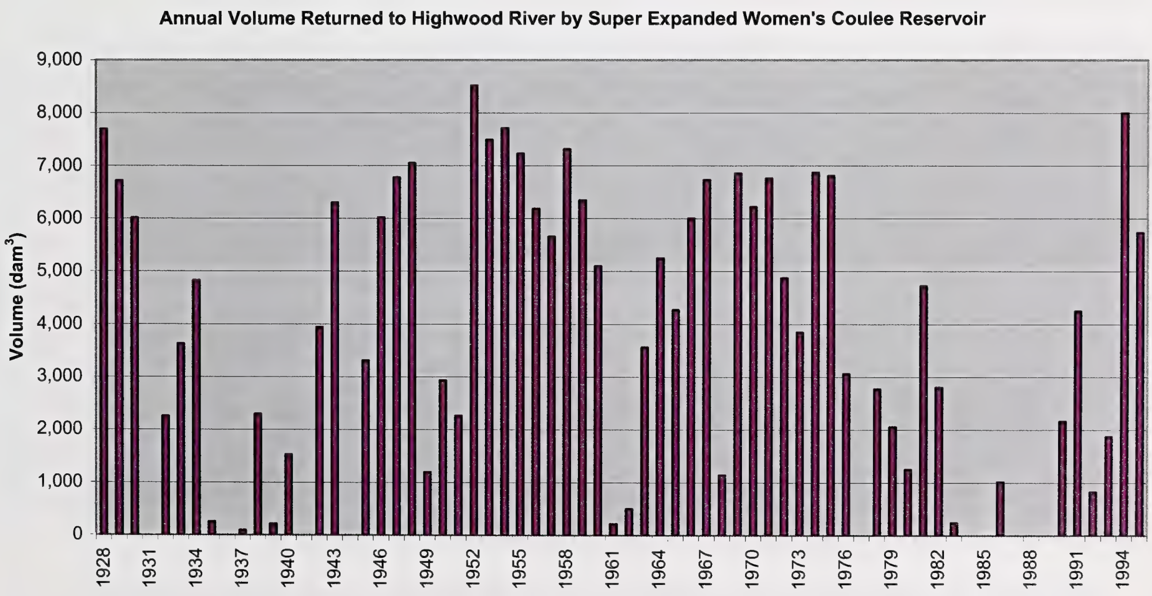


Figure 6. Annual volume of water returned to the Highwood River from Super Expanded Women's Coulee Reservoir.

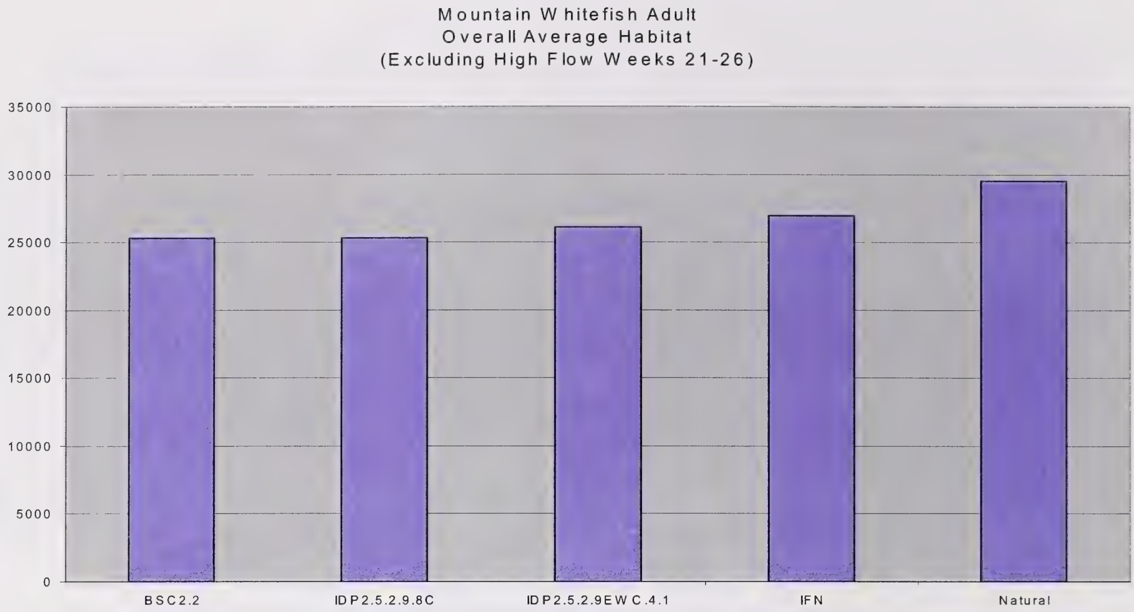


Figure 7 Mountain Whitefish adult average habitat, excluding high flow weeks 21 to 28.

BC2.2 = Base Case (pre-project conditions).
IDP2.5.2.9.8 / IDP2.5.2.9.8C = Preferred scenario without storage.
IDP2.5.2.9EWC4.1 = Preferred scenario with storage.
IFN = Habitat conditions for recommended technical IFN.
Natural = Natural flow conditions.

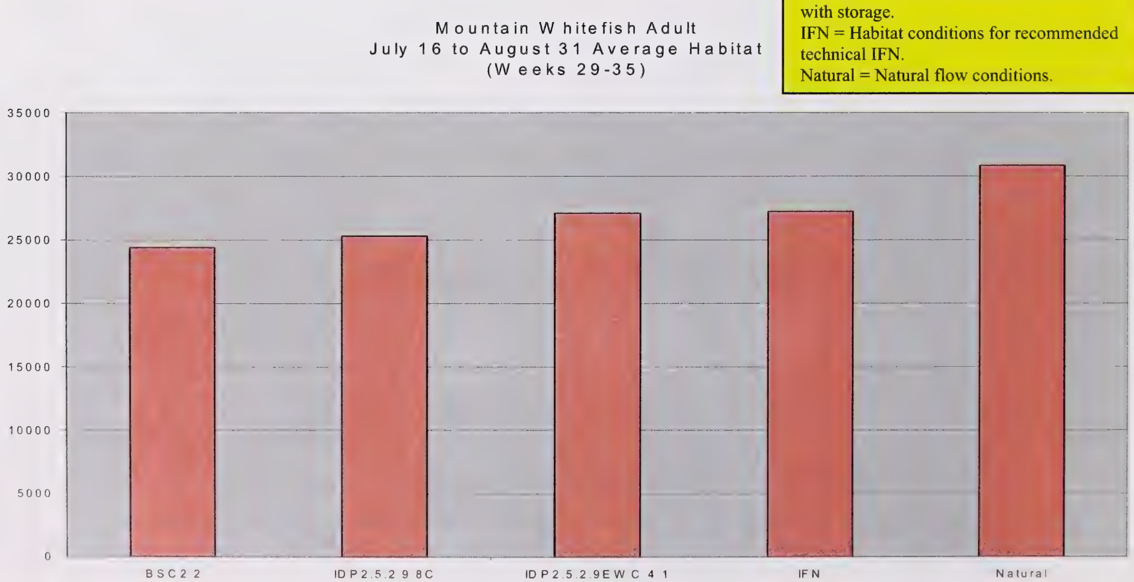


Figure 8 Mountain Whitefish adult average habitat for low-flow period July 16 to August 31.

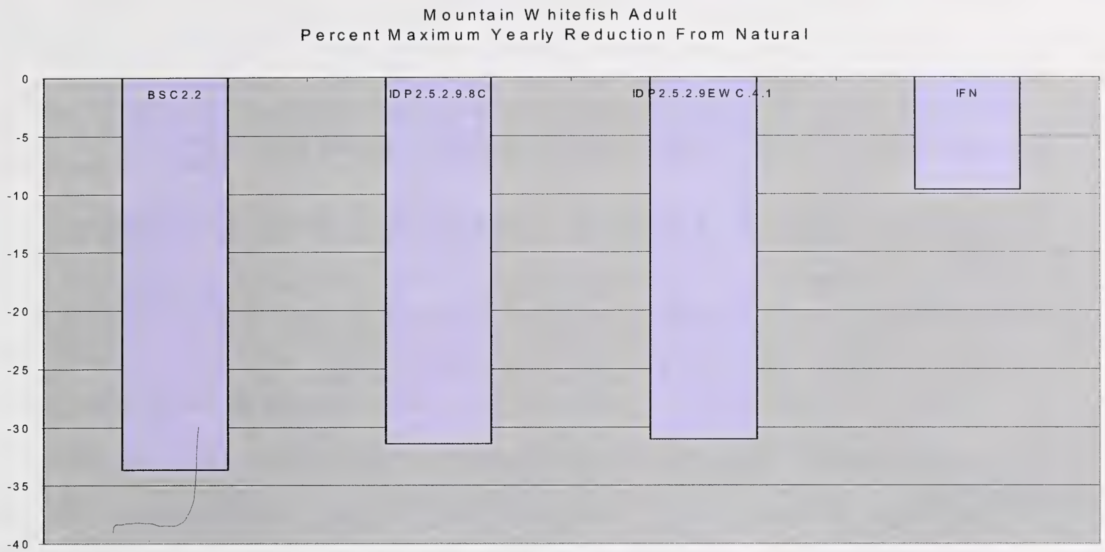


Figure 9 Mountain Whitefish adult percent maximum annual reduction from natural habitat.

BC2.2 = Base Case.
IDP2.5.2.9.8 / IDP2.5.2.9.8C = Preferred scenario without storage.
IDP2.5.2.9EWC4.1 = Preferred scenario with storage.
IFN = Habitat conditions for recommended technical IFN.
Natural = Natural flow habitat conditions.

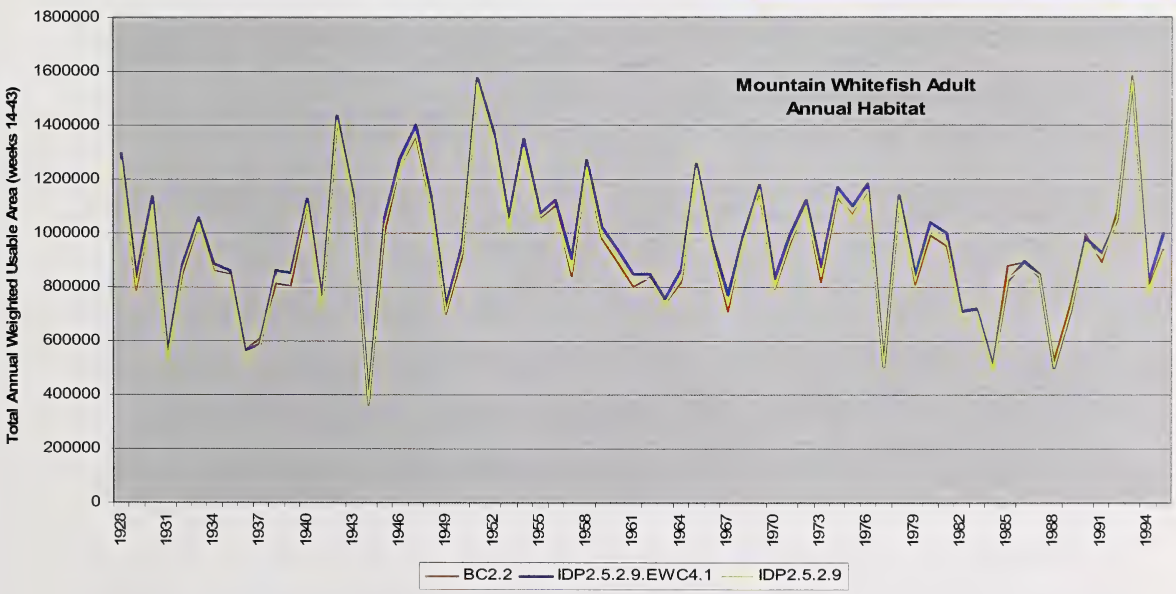


Figure 10 Mountain Whitefish adult annual habitat, 1928 to 1995.

Technical Note

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Future Water Demand Projections

Issues:
- What are the purposes and magnitudes of future water demands within the various sub-basins in the study area?
- What is the monthly distribution of future water demands?
- What future demands are most significant in the development of the Highwood Diversion Plan?

Discussion:

- **Introduction**

The Joint Review Panel (Natural Resources Conservation Board and the Canadian Environmental Assessment Agency) established to review an application by the Alberta Government to construct the Little Bow Project and implement the Highwood Diversion Plan, gave provincial approval for three of the four components of the project -- the construction of the Little Bow River Reservoir, construction of the Clear Lake diversion, and expansion of the Little Bow diversion (NRCB 1998). The Panel deferred a decision on the fourth component, the Highwood Diversion Plan, as it applied to the low flow season of late July and August, pending the receipt and review of additional information. Among other things, the Panel asked that the revised Highwood Diversion Plan should be capable of meeting known future demands, and, if possible, water should be reserved for future demands that are unknown at this time. In June 2000, the Panel agreed that the additional information would be best provided within the broader context of the Highwood Water Management Plan (HWMP). The Panel requested that the HWMP investigate the full range of options for addressing existing and future water demands in the basin.

Estimates of 2001 mean annual actual use for each purpose in the study area were prepared based upon several purpose-specific factors and considerations (Fact Sheet: **Current Actual Water Use** (Hart 2003a)). Both basin uses and mainstem uses were estimated (sidebar).

> **Mainstem Demands:** For the purposes of this study, mainstem demands are those demands that have potential to reduce Highwood River flows in the critical fish habitat reach, Aldersyde to the Sheep River confluence. They include demands drawing water from the Highwood River, as well as demands along Women's Coulee, mainstem Mosquito Creek downstream of the Women's Coulee confluence, and mainstem Little Bow River upstream of the Little Bow River Reservoir. Generally, water users in these parts of the Little Bow Basin rely on diversions from the Highwood River to meet their needs. The Little Bow River downstream of the reservoir is significant, but less critical since users will be supplied with water from storage during low flow/high demand periods.

This Technical Note relates to **estimates of the increase in water demands** to approximately the Year 2021 level of development. Future water demands are dependent on numerous variables that are difficult to predict. Human and livestock population growths, economic circumstances, technology, climate change and several other variables all affect future water demand. While each of these variables is difficult to predict, effective water management planning must consider future water uses. Therefore, an attempt must be made. For Highwood River Basin water management planning, some potential uses are more significant than others because of their magnitudes or their locations and probable sources. For the purposes of this study, efforts were focused on uses that could have the greatest impact

on development of the Highwood Diversion Plan (mainstem uses), and uses that are likely to be largest in magnitude. Estimates are believed to be on the "high side". The rationale for high-side demand estimates is that, in the face of uncertainty, over estimating future demands would represent a more cautious approach in determining impacts and making allocation recommendations than under estimating demands. **In light of the approach taken, population estimates and other information from this Technical Note should not be used for purposes other than Highwood River Basin water management planning.**

- **Projected Water Demands**

The estimated increases in water demand are summarized for each sub-basin in the study area in Tables 5, 6 and 7. Mainstem water demands are identified in bold type on the tables. Following is a summary of the bases for the demand estimates.

○ **Irrigation**

Moratoria on new irrigation licences in the Little Bow River Basin and have been in place since November 1983, and in the Highwood River Basin since 1985. Applications received since the moratoria were imposed have been held in abeyance. Water demands for the projects that are in abeyance within each sub-basin have been estimated based on crop and system mixes similar to existing projects. Results are shown in Tables 5, 6 and 7. The demands shown in the tables are based on the average annual demand for the period 1928 to 1995, with a typical monthly distribution.

While the demands based upon received irrigation applications are interesting, they are not necessarily a good indication of future irrigation demands. The moratoria have been in place for 20 years. Producers desiring irrigation would not necessarily prepare an application for a licence knowing that the application would not be processed. Also, it is not known whether or not those producers that have applied still desire to irrigate. Historically, interest in irrigation in the more southerly and easterly portions of the study area (Lower Little Bow and Clear Lake areas), where the heat units and moisture deficits are highest, has been higher than the more northerly and westerly portions (Upper Mosquito Creek, Upper Little Bow, Highwood and Sheep Rivers). Like other parts of southern Alberta, demand in the Lower Little Bow and Clear Lake areas would probably be limited only by the amount of irrigable land that could be economically supplied from the source streams. This demand would likely exceed the available water supply. Irrigation demands in areas further north and west also exist and should not be excluded from future consideration.

○ **Livestock**

Secure supplies of good quality water are essential for the cattle industry. Estimates of current actual withdrawals and consumptive uses (consumption plus losses) were based on domestic herd and feedlot cattle populations within the sub-basins of the study area, and average unit consumption rates. The procedures for estimating the cattle populations in the study area and the consumption rates are discussed in a separate Fact Sheet, **Livestock Water Use** (Hart 2003b). Ten percent of the computed value for cows, calves and feeders was added to account for other types of livestock (pigs, horses, chickens, sheep, etc.).

The same procedures were followed for estimating future stock water demands.

○ Domestic Cattle -- Range cattle in the study area are generally watered from wells or from surface water from tributary streams, many of which are intermittent. The quantity of water used by range cattle is not significant in terms of mainstem issues being addressed in developing a revised Highwood Diversion Plan. It may be significant to other issues that will be addressed in the Highwood Water Management Plan, such as groundwater use and availability.

The range cattle herds in the M.D. of Foothills, M.D. of Willow Creek and the County of Vulcan (municipalities that make up most of the study area) have grown by 11.4%, 5.5% and 15.9%

respectively over the past five years (1996 and 2001 census data). Can that growth rate be maintained? Continued growth is dependent upon the supply of pasture and winter feed, and, of course, market conditions. Native range pastures in the study area are judged to be stocked at or near capacity (AAFRD 2003). Increased production from tame pasture may provide some additional grazing potential. Domestic cattle herds are commonly grazed on lands outside the study area in the summer months and returned to the area for winter feeding, shelter and calving. Irrigation expansion in the Lower Little Bow and Clear Lake areas will greatly increase the supply of winter feed in the study area.

Range cattle population growth was estimated based on the portion of each municipality within each sub-basin, and the growth rates experienced in the municipalities during the five-year period 1996 to 2001 (Table 1).

- Feeders – Water supplies for feedlots in the study area are primarily from wells or mainstem streams. Feedlot water supplies could have a minor influence on development of the Highwood Diversion Plan. For the purposes of this study, it is assumed that the water supply for all future feedlots will be sourced from mainstem streams.

The feedlot population for 2001 was based upon an inventory of feedlots in the study area and their reported or estimated capacities. It is difficult to estimate the future of the feedlot industry in the study area. In addition to market conditions, significant factors are:

- Separation distances to minimize nuisance odours.
- Availability of local forage.
- Availability of water.
- Availability of well-drained landscapes.

An AAFRD (2003) screening-level study evaluated conditions in all rural municipalities in Alberta to determine growth potential for 5000 head backgrounding feedlots and 20,000 head finishing feedlots (sidebar). The analysis indicated that 15% to 30% of the quarter sections in the study area generally met the separation, forage, water and landscape criteria for 5000 head feedlots. The separation distances for 20,000 head feedlots are considerably higher than for 5000 head feedlots. Areas that are urban or where rural acreages are common, or where there are existing intensive feeding operations typically do not meet the separation criteria. Nonetheless, the study indicated that rural municipalities in the study area have some potential for large feedlots. The availability of locally grown forage will greatly increase in the Clear Lake area and the Lower Little Bow Sub-basin with the 8100 ha of irrigation expansion.

Feedlots: Backgrounding lots feed lighter weight calves, typically 500 to 600 pounds, forage-based rations to add size and weight. Backgrounded calves and yearlings weighing 800 to 950 pounds are sent to finishing feedlots and are fed high grain rations to produce slaughter-weight cattle. Cattle are generally ready for slaughter at 14 to 22 months of age, weighing 1000 to 1400 pounds.

For the purposes of this study, the feedlot expansion potential to 2021 was assumed to be as follows:

	5000 head feedlots	20,000 head feedlots
• Highwood Basin	3	
• Sheep River Basin	2	
• ULB Sub-basin	1	
• MC Sub-basin and Clear L.	3	1
• LLB Sub-basin	3	1

Estimated cattle populations in 2001 and increases to 2021 for each sub-basin are shown in Table 1.

- Water Requirements – AAFRD water consumption values were used to estimate requirements for the domestic herd. Feedlot water use is fairly consistent throughout the year, with high hot-weather requirements offset by lower cattle numbers in the feedlots. A consumptive use value of 6.0 imperial gallons per day (27.3 l/d) for the full capacity of the feedlot was used to estimate feedlot water use.

  Cattle water requirements for each sub-basin were estimated based on the resident cattle populations and average consumption rates. Seasonal variations in the resident domestic herd were considered. Water requirements were increased by 10% to account for non-cattle livestock consumption. The resulting increases in livestock demands to the year 2021 are shown in Table 2.

- **Other agricultural uses**

Agricultural uses in the study area, other than irrigation and stock water, include minor uses related to fish farming, and small market gardens. Actual withdrawal and consumption for 2001 were assumed to be 80 percent of licensed values (AMEC. 2001). Increases in demand to 2021 were assumed to be 50% of current uses.

- **Municipal and rural domestic**

Procedures for estimating 2001 water use and return flows for communities and rural domestic users in the study area are discussed in a separate Fact Sheet, **Municipal and Rural Domestic Water Use** (Hart 2003c). Procedures for estimating demand increases to 2021 are based on the 2001 procedures; namely, population projection times average per capita consumption.

- Population – Census data for 1991, 1996 and 2001 was used to determine annual growth rates for communities and rural municipalities in the study area (Table 3). The annual growth rates for the larger communities of Okotoks, High River, Nanton and Vulcan were much higher for the 1996 to 2001 period than for the 1991 to 1996 period. The growth rates for the Towns of Okotoks and High River were particularly high at 6.5% and 4.9%, respectively. These two communities were probably fueled by Calgary's hot economy and growth rate over the past five years (growth rate = 2.73%/yr for 1996 to 2001, compared with 1.56%/yr for 1991 to 1996). For the purposes of this study, the 1996 to 2001 growth rate was assumed for population projections for Okotoks, High River and Vulcan.

  The Town of Nanton has experienced considerable growth in recent years. Town officials feel that their current annual growth rate is higher than the 1.5% computed from the 1996 and 2001 census data.[3] This growth is at least in part fueled by Calgary, Okotoks and High River's growth. Seniors seeking low-cost retirement living are settling in communities that provide all essential services, but have lower housing costs than the larger centres. Some residents of Nanton are commuting to Calgary for employment. Through discussions with Town officials, a growth rate of 3.2%/yr was considered to be representative of growth in recent years, and appropriate for population projections.

  For all other communities and rural areas, the 1991 to 2001 growth rate tended to be higher than the 1996 to 2001 growth rate. The 10-year growth rate (1991 to 2001) was assumed for these areas. The population estimates based on these growth rates may be on the high side, and therefore conservatively high in terms of water demand estimates.

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[3] Personal communication with Bill Szabon, Councillor and Mary Mobley, Administrator.

- Per Capita Consumption – Unit consumption values used for the 2001 water use estimates were reduced by five percent to reflect conservation measures that may be taken in the future. Unit consumption values for rural domestic users and hamlets were taken unchanged from the 2001 estimates.

- Return Flow – Return flow expressed as a percentage of the withdrawal demands assumed to be the same as recorded and estimated values used for the 2001 water use estimates.

Increases in consumptive water demands to 2021 for urban and rural users in each of the sub-basins are summarized in Table 4. There are several unique situations in the study area that are noteworthy.

- The Town of High River, Cargill Foods and the M. D. of Foothills withdraw water from the Highwood River (via three or more wells), and return their wastewater to Frank Lake in the Little Bow River Basin. The entire withdrawal of these three users represents a depletion on the Highwood River. Water is lost from Frank Lake through evaporation, transpiration, and spills to the Little Bow River. Spills are expected to occur in 40 to 60 percent of the years, in essence, representing a transfer of water from the Highwood River to the Little Bow River.

- Several communities in the study area treat their wastewater in lagoon systems that have little or no return flow. If releases are necessary, they are made in fall and/or spring, both of which are outside the critical high demand-low flow period that is the focus for developing the Highwood Diversion Plan. Communities with mainstem water withdrawals and little or no return flow are Cayley, Carmangay, and Vulcan.

- Nanton withdraws its water from a spring, a well and Mosquito Creek. About 50% of the Town's 2001 water withdrawal was from Mosquito Creek. The spring and well are at or near capacity. It was assumed that all increases in water demand would be sourced from Mosquito Creek. The Town's return flow is released to Mosquito creek on a continuous basis. During some parts of the year Nanton's return flow to Mosquito Creek exceeds its withdrawal from the creek, and the Town is a net contributor to flow in the creek.

- None of the Town of Vulcan's return flow is released to the source stream, the Little Bow River.

- **Industrial**

The largest industrial water user in the study area is Cargill Foods. The Company's 2001 average monthly use and return flow were estimated from records for years 2000 and 2001. Industrial users also include water flood projects for the petroleum industry, water bottling, aggregate washing and other categories. It was assumed that increases in industrial water demands in the period 2001 to 2021 would be proportional to the increase in population within each sub-basin, plus one major industrial user located near the Little Bow River Reservoir. The major user would have a water use and return flow pattern similar to Cargill Foods current use and return flow. Withdrawal would be from the Little Bow River Reservoir, and return flow would be to the Little Bow River downstream of the reservoir.

- **Recreation/Conservation**

Recreation/conservation projects in the study area include golf courses, parks and wetland projects. It was assumed that recreational and wetland water demands would increase by 50% over the period 2001 to 2021 (Hydroconsult 1999).

Key Findings

- Table 5, 6, and 7 provide an estimate of increases in water demand over the current level of use. These tables provide a basis for developing demand files for scenarios involving future water demands. Scenario demand files may not necessarily include all future demands. For instance, a scenario may explore the impacts of future non-irrigation demands only.

- For purposes of developing the Highwood Diversion Plan, mainstem demands in July and August are most significant. During this period, irrigation demands are typically high, Highwood River flows are typically low and water temperatures are highest due to more frequent and prolonged high air temperatures. Critical fish habitat conditions can occasionally extend into June and September.

- Mainstem demands in all sub-basins are highest in the June, July, August period, primarily due to high irrigation demands. In the Highwood River Basin, the combined municipal and industrial demand is significant, comprising (potentially) almost 35% of the total July demand, primarily as a result of the Town of High River/Cargill Foods water supply system. Non-irrigation expansion over the next 20 years could increase the July demand by about 631 dam^3, or by about 35% of total current demand (Table 8). (In this analysis it was assumed that all ten production wells are either fed from the river or are intercepting groundwater flows that would normally enter the river. This assumption may have to be examined.)

- Table 8 summarizes the estimated mainstem demands in July, the highest demand month, and annually for the current level of development, and for the additional demand to 2021. Fully meeting the additional non-irrigation demands in July, the highest demand month, by diversions from the Highwood River would deplete Highwood River flows by the following amounts:

Highwood River Sub-basin	0.236 m^3/s
Upper Little Bow Sub-basin	0.012 m^3/s
Mosquito Creek Sub-basin (inc. W. Coulee)	0.027 m^3/s
Lower Little Bow Sub-basin (without L. Bow Res.)	0.014 m^3/s

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Table 1 Livestock population estimates, 2001 and 2021.

2001

	Range	Feedlots	TOTAL
Sheep	31876	10000	57835
Highwood	44627	94000	80969
Mosquito	25754	17000	41623
Upper L. Bow	26364	34000	45628
Lower L. Bow	35581	0	50424
GRAND TOTAL	164202	155000	276479

2021

	Range		Feedlots				TOTAL
		increase from 2001	2001	New 5000 Head	New 20,000 Head	inc fr 2001	
Sheep	49085	54%	10000	10,000		100%	69085
Highwood	60772	36%	94000	15,000		16%	169772
Mosquito	30449	18%	17000	15000	20000	206%	82449
Upper L. Bow	39269	49%	34000	5000		15%	78269
Lower L. Bow	49716	40%	0	15000	20000		84716
GRAND TOTAL	228300	39%	155000	60000	40000	65%	483300

Table 2 Livestock water demand estimates.

2001 stockwater demands

	Sheep Sub-basin				Highwood Sub-basin				Mosquito Sub-basin				Upper Little Bow Sub-basin				Lower Little Bow Sub-basin			
	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total
January	36.6	2.3		40.3	117.9	11.6		129.6	37.9	3.6		41.5	48.8	4.8		53.6	34.2	3.1		37.4
February	38.3	2.3		42.1	120.3	11.6		131.9	38.9	3.6		42.6	49.9	4.8		54.7	35.5	3.1		38.7
March	39.9	2.3	245	288.9	122.7	11.6	218	352.3	40.0	3.6	181	224.6	51.1	4.8	0	55.8	36.8	3.1	50	90.0
April	41.5	2.3	245	290.7	125.0	11.6	218	354.7	41.1	3.6	181	225.7	52.2	4.8	0	56.9	38.1	3.1	50	91.3
May	35.5	2.3		39.1	116.2	11.6		127.9	36.3	3.6		39.9	47.8	4.8		52.5	31.5	3.1		34.6
June	21.3	2.3		23.4	98.7	11.6		110.3	26.7	3.6		30.3	39.0	4.8		43.8	18.1	3.1		21.3
July	23.3	2.3		25.6	98.7	11.6		110.3	26.7	3.6		30.3	39.0	4.8		43.8	18.1	3.1		21.3
August	23.3	2.3		25.6	98.7	11.6		110.3	26.7	3.6		30.3	39.0	4.8		43.8	18.1	3.1		21.3
September	23.3	2.3		25.6	98.7	11.6		110.3	26.7	3.6		30.3	39.0	4.8		43.8	18.1	3.1		21.3
October	23.3	2.3		25.6	98.7	11.6		110.3	26.7	3.6		30.3	39.0	4.8		43.8	18.1	3.1		21.3
November	38.3	2.3		42.1	120.3	11.6		131.9	38.9	3.6		42.6	49.9	4.8		54.7	35.5	3.1		38.7
December	35.0	2.3		38.5	115.6	11.6		127.2	36.8	3.6		40.4	47.7	4.8		52.5	32.9	3.1		36.1
Totals	379.7	28.0	490.0	897.7	1331.4	139.5	436.0	1906.9	403.5	43.5	362.0	809.0	542.5	57.3		599.8	335.3	37.8	100.0	473.1

Additional stockwater demands to 2021

	Sheep Sub-basin				Highwood Sub-basin				Mosquito Sub-basin				Upper Little Bow Sub-basin				Lower Little Bow Sub-basin			
	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total	Cattle	Other	Losses	Total
January	23.5	2.3		25.8	18.9	1.9		20.7	33.0	3.3		36.2	14.5	1.4		15.9	42.3	4.1		46.5
February	24.4	2.3		26.7	19.2	1.9		21.1	33.2	3.3		36.4	15.0	1.4		16.4	42.9	4.1		47.0
March	25.3	2.3		27.6	19.6	1.9		21.5	33.4	3.3		36.6	15.6	1.4		16.9	43.4	4.1		47.5
April	26.2	2.3		28.5	20.0	1.9		21.9	33.5	3.3		36.8	16.1	1.4		17.5	43.9	4.1		48.0
May	22.9	2.3		25.2	18.6	1.9		20.5	32.7	3.3		36.0	13.9	1.4		15.3	41.2	4.1		45.4
June	15.3	2.3		17.6	15.8	1.9		17.6	31.0	3.3		34.2	9.7	1.4		11.0	35.9	4.1		40.0
July	16.4	2.3		18.7	15.8	1.9		17.6	31.0	3.3		34.2	9.7	1.4		11.0	35.9	4.1		40.0
August	16.4	2.3		18.7	15.8	1.9		17.6	31.0	3.3		34.2	9.7	1.4		11.0	35.9	4.1		40.0
September	16.4	2.3		18.7	15.8	1.9		17.6	31.0	3.3		34.2	9.7	1.4		11.0	35.9	4.1		40.0
October	16.4	2.3		18.7	15.8	1.9		17.6	31.0	3.3		34.2	9.7	1.4		11.0	35.9	4.1		40.0
November	24.4	2.3		26.7	19.2	1.9		21.1	33.2	3.3		36.4	15.0	1.4		16.4	42.9	4.1		47.0
December	22.7	2.3		25.0	18.5	1.9		20.4	32.8	3.3		36.1	13.9	1.4		15.3	41.8	4.1		45.9
Totals	250.2	27.6	0.0	277.8	213.0	22.3	0.0	235.3	386.5	39.2	0.0	425.7	152.3	16.7		169.0	477.8	49.5		527.3

Table 3 Projected population by community and sub-basin.

Location	Population			Growth Rates[1]			2021 Population Projections				Comments
							2021	Hydrocon 1999		AMEC	
	1991 Census	1996 Census	2001 Census	91-'96	96-'01	91-'01	Estimate	Med G. Rate	High G. Rate	2001	
SHEEP RIVER BASIN											
Okotoks	6723	8510	11664	1.048270	1.065083	1.056643	41164	16803	17790	16803	Estimates for Okotoks and the MD based on highlighted
Black Diamond	1623	1811	1866	1.022163	1.006002	1.014050	2467	2670	2763	2670	growth rates are much higher than Hydrocon or
Turner Valley	1352	1527	1608	1.024643	1.010391	1.017492	2275	2320	2405	2320	AMEC estimates. These areas are fueled by
Rural (total MD 31)	10909	14331	16764	1.056084	1.031859	1.043901					Calgary's hot economy. Earlier studies underestimated
59% of MD 31			9891				23358	13772	14410	13772	population growth in these areas.
Basin Total			25029				45905	35565	37368	36565	
HIGHWOOD RIVER BASIN											
High River[2]	6269	7359	9345	1.032581	1.048944	1.040730	24301	10848	11215	12084	Same comment as above with respect to High River
Longview	271	303	300	1.022574	0.998012	1.010218	368	402	411	402	and the rural areas.
Eden Valley Reserve	370	432	509	1.031470	1.033348	1.032409	963	989	1059	989	
Rural (total MD 31)	10909	14331	16764	1.056084	1.031859	1.043901					
25% of MD 31			4191				9897	5900	6174	5900	
Basin Total			14345				35529	18139	18859	19375	
MOSQUITO CREEK BASIN											
Cayley	229	334	344	1.078406	1.005918	1.041531	776			387	
Nanton	1589	1665	1841	1.009388	1.020300	1.014829	3457	1927	1952	2164	Nanton's growth rate estimated to be 1.032 based on
Rural (total MD 26)	4764	5106	5412	1.013962	1.011708	1.012835					comments from town officials (see text).
15.5% of MD 26			839				1083	1057	1084	1057	
Sub-basin Total			3024				5316			3608	
UPPER LITTLE BOW BASIN											
Vulcan	1466	1537	1762	1.009504	1.027700	1.018561	3043	1988	2034	1988	
Blackie	303	301	310	0.998676	1.005910	1.002287	324			349	
Rural (total County 2)	3648	3808	3778	1.008622	0.998419	1.003508					
15.8% of County 2			597				640	255	262	802	
Sub-basin Total			2072				4008			3139	
LOWER LITTLE BOW BASIN											
Carmangay	251	258	255	1.005516	0.997664	1.001582	263			299	Estimates are close to AMEC estimates.
Champion	351	362	355	1.006191	0.996102	1.001134	363			420	
Barons	262	285	284	1.016971	0.999297	1.008096	334			331	
Stavely	478	453	442	0.989314	0.995096	0.992200	378			525	
Rural (total County 2)	3648	3808	3778	1.008622	0.998419	1.003508					
35.3% of County 2			1334				1430			1796	
Sub-basin Total			2670				2768			3371	

[1] Shaded growth rates and population estimates adopted for water use projections.

Table 4 Water demand estimates for urban and rural municipalities in the study area.

Location	2001						2021						Increase from 2001 to 2021			
	Census	m^3/c-d	Withdrawal dam^3	Return %	Return dam^3	Cons Use dam^3	Pop'n Estimate	m^3/c-d	Withdrawal dam^3	Return %	Return dam^3	Cons Use dam^3	Withdrawal dam^3	Withdrawal % inc.	Return dam^3	Cons Use dam^3
SHEEP RIVER BASIN																
Okotoks	11664	0.480	2043.5	65%	1328.3	715.2	41164	0.456	6851	65%	4453	2398	4808	235.3%	3125	1683
Black Diamond	1866	0.517	352.4	72%	253.7	98.7	2467	0.491	442	72%	318	124	90	25.5%	65	25
Turner Valley	1608	0.462	270.9	72%	195.0	75.9	2275	0.439	364	72%	262	102	93	34.5%	67	26
Rural (59% of MD 31)	9890	0.341	1231.0	75%	923.3	307.8	23358	0.341	2907	75%	2180	727	1676	136.2%	1257	419
Subtotal	25028		3897.8		2700.2	1197.6	69264		10565		7215	3351	6667	171.1%	4514	2153
HIGHWOOD RIVER BASIN																
High River	9345	0.828	2824.2	55%	1553.3	1270.9	24301	0.787	6977	55%	3837	3140	4153	147.0%	2284	1869
Longview	300	0.493	54.0	56%	30.2	23.8	368	0.468	63	56%	35	28	9	16.4%	5	4
Eden Valley Reserve -- Institutional			15.0	75%	11.3	3.7			28	75%	21	7	13	89.2%	10	3
-- Rural Domestic	509	0.341	63.4	75%	47.6	15.9	963	0.341	120	75%	90	30	56	89.1%	42	14
Rural (25% of MD 31)	4191	0.341	521.6	75%	391.2	130.4	9897	0.341	1232	75%	924	308	710	136.2%	533	178
Subtotal	14345		3478.2		2033.6	1444.7	35529		8420		4908	3512	4942	142.1%	2874	2068
TOTAL HIGHWOOD	39373		7376.0		4733.8	2642.2	104793		18985		12122	6863	11609	157.4%	7388	4221
MOSQUITO CREEK BASIN																
Cayley	344	0.341	42.8	insig.	0.0	42.8	776	0.341	97	insig.	0	97	54	125.7%	0	54
Nanton	1841	0.452	304.0	63%	191.5	112.5	3457	0.429	542	63%	341	200	238	78.2%	150	88
Rural (15.5% of MD 26)	838	0.341	104.3	75%	78.2	26.1	1083	0.341	135	75%	101	34	30	29.2%	23	8
Subtotal	3023		451.1		269.7	181.4	4611		773		442	331	322	71.4%	173	149
UPPER LITTLE BOW BASIN																
Vulcan	1762	0.563	362.4	0%	0.0	362.4	3043	0.535	594	0%	0	594	232	63.9%	0	232
Blackie	310	0.341	38.6	70%	27.0	11.6	324	0.341	40	70%	28	12	2	4.6%	1	1
Rural (Vulcan County 2 density)	636	0.341	79.2	75%	59.4	19.8	640	0.341	80	75%	60	20	0	0.6%	0	0
Subtotal	2708		480.1		86.4	393.8	4008		714		88	626	234	48.7%	2	232
LOWER LITTLE BOW BASIN																
Carmangay	255	0.493	45.9	insig.	0.0	45.9	263	0.468	45	insig.	0	45	-1	-2.0%	0	-1
Champion	355	0.493	63.9	insig.	0.0	63.9	363	0.468	62	insig.	0	62	-2	-2.9%	0	-2
Barons	284	0.493	51.1	0%	0.0	51.1	334	0.468	57	0%	0	57	6	11.6%	0	6
Stavely	442	0.493	79.5	insig.	0.0	79.5	378	0.468	65	insig.	0	65	-15	-18.7%	0	-15
Rural (Vulcan County 2 density)	1403	0.341	174.6	75%	131.0	43.7	1430	0.341	178	75%	134	45	3	2.0%	3	1
Subtotal	2739		415.0		131.0	284.1	2768		407		134	273	-8	-2.0%	3	-11
TOTAL LITTLE BOW[1]	8470		1346.2		487.1	859.2	11387		1894		664	1230	548	40.7%	177	371

Notes: 1. Total Little Bow includes Upper and Lower Little Bow, and Mosquito Creek.

Table 5 Highwood River Basin projected additional consumptive water use to 2021.

Highwood River Sub-basins (Excluding Sheep River Sub-basin)		Mean Monthly Demand (dam³) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Upstream of Women's Coulee Diversion														
Irrigation	**Mainstem**													**0.0**
	Tributaries													0.0
Stock[1]	+ GW	6.0	6.2	18.5	18.8	5.8	4.1	4.1	4.1	4.1	4.1	6.2	5.7	87.6
	Mainstem F'lots	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**12.3**	**147.7**
Other Agric														
Recreation														
Municipal	**Towns, Villages**	**0.5**	**0.5**	**0.5**	**0.6**	**0.7**	**0.9**	**0.9**	**0.9**	**0.8**	**0.7**	**0.5**	**0.5**	**8.0**
	Co-op													
	Rural Domestic[2]	2.6	2.6	2.6	2.6	2.6	49.8	49.8	49.8	7.6	2.6	2.6	2.6	178.0
Industrial[3]		**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**39.4**	**472.9**
Totals	**Mainstem**	**52.2**	**52.2**	**52.2**	**52.3**	**52.4**	**52.6**	**52.6**	**52.6**	**52.5**	**52.4**	**52.2**	**52.2**	**628.5**
	Tributaries + GW	8.6	8.8	21.2	21.4	8.5	53.8	53.8	53.8	11.6	6.7	8.8	8.4	87.6
Women's Coulee Diversion to Little Bow Diversion														
Irrigation	**Mainstem**													**0.0**
Stock	**Mainstem**													
	Tributaries (losses only)													
Other Agric														
Recreation[4]					**0.8**	**9.0**	**19.8**	**24.3**	**12.4**	**3.9**				**70.2**
Municipal	**High River**	**269.9**	**269.9**	**269.9**	**332.2**	**373.8**	**415.3**	**436.1**	**436.1**	**394.5**	**373.8**	**290.7**	**290.7**	**4153**
	Foothills M.D.	**5.4**	**5.4**	**5.4**	**6.6**	**7.4**	**8.3**	**8.7**	**8.7**	**7.9**	**7.4**	**5.8**	**5.8**	**82.7**
Industrial	**Mainstem**	**70.1**	**70.1**	**75.1**	**80.0**	**94.7**	**99.6**	**104.5**	**99.6**	**94.7**	**80.0**	**70.1**	**60.3**	**999.0**
Totals	**Mainstem**	**345.5**	**345.5**	**350.4**	**419.7**	**484.9**	**543.0**	**573.6**	**556.8**	**501.0**	**461.2**	**366.6**	**356.8**	**5304.9**
	Tributaries + GW													
Little Bow Diversion to Aldersyde														
Irrigation[5]	**Mainstem**				**9.7**	**103.7**	**228.4**	**280.3**	**143.4**	**44.6**				**810.0**
	Tributaries													
Stock	Tributaries + GW													
Other Agric														
Recreation	**Wetlands[4]**				**55.0**	**55.0**	**55.0**							**165.0**
Municipal	Subdivisions	Included with rural domestic.												
Industrial	Other	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**57.2**
Totals	**Mainstem**	**4.8**	**4.8**	**4.8**	**69.5**	**163.4**	**288.2**	**285.0**	**148.1**	**49.3**	**4.8**	**4.8**	**4.8**	**1032.2**
	Tributaries + GW													
Aldersyde to Sheep River Confluence														
Irrigation	**Mainstem**													**0.0**
Stock	Tributaries (losses only)													
Other Agric														
Recreation	Golf	Not developed.												
Municipal	Subdivision	Water from High River.												
Industrial														
Totals	**Mainstem**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Tributaries + GW													
Sheep River Confluence to Mouth														
Irrigation	**Mainstem**													**0.0**
Stock[3]	Tributaries (losses only)													
Other Agric														
Recreation														
Municipal	Subdivision	Included with rural domestic.												
Industrial														
Totals	**Mainstem**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Tributaries + GW													
Basin Total	**Mainstem**	**402.4**	**402.4**	**407.3**	**541.5**	**700.8**	**883.7**	**911.2**	**757.6**	**602.8**	**518.4**	**423.6**	**413.8**	**6965.6**
	Tributaries + GW	8.6	8.8	21.2	21.4	8.5	53.8	53.8	53.8	11.6	6.7	8.8	8.4	87.6

Notes:

1. Increase in stock water consumptive use for the entire basin is included in the value noted for Upstream of Women's Coulee Diversion. Increase in feeder use assumed to be mainstem use.
2. Increase in rural domestic consumptive water use for the entire basin is included in the value noted for Upstream of Women's Coulee Diversion.
3. Increase in industrial consumptive water use is assumed to be equal to the increase in basin population.
4. Increase in recreational consumptive use assumed to be 50% (Hydroconsult 1999).
5. Increase in irrigation consumptive use based upon licence applications and crop and system mixes similar to existing irrigation.

Table 6 Sheep River Basin projected additional consumptive water use to 2021.

Sheep River Sub-basin		Mean Monthly Demand (dam^3)												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sheep River Sub-basin														
Irrigation[1]	**Mainstem**													
Stock[2]	Tributaries + GW	8.0	8.3	57.2	57.5	7.7	4.6	5.1	5.1	5.1	5.1	8.3	7.6	179.6
	Mainstem F'lots	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**8.2**	**98.2**
Other Agric[3]	**Gardens**	**0.0**	**0.0**	**0.0**	**2.8**	**29.5**	**65.0**	**79.7**	**40.8**	**12.7**				**230.5**
Recreation[4]	**Golf + Parks**				**2.1**	**22.5**	**49.6**	**60.8**	**31.1**	**9.7**				**175.8**
Municipal	**Towns, Villages**	**91.7**	**91.7**	**91.7**	**134.9**	**163.7**	**192.5**	**206.9**	**206.9**	**178.1**	**163.7**	**106.1**	**106.1**	**1734.0**
	Rural Domestic	5.9	5.9	5.9	5.9	5.9	118.2	118.2	118.2	17.6	5.9	5.9	5.9	419.0
Industrial[5]		**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**76.3**	**915.0**
Totals	**Mainstem**	**176.1**	**176.1**	**176.1**	**224.2**	**300.1**	**391.5**	**431.9**	**363.3**	**284.9**	**248.1**	**190.5**	**190.5**	**3153.4**
	Tributaries + GW	13.8	14.2	63.0	63.4	13.6	122.8	123.2	123.2	22.7	10.9	14.2	13.5	598.6

Notes:

1. Irrigation demand increase not estimated.
2. Increase in feeder livestock consumptive water use assumed to be mainstem.
3. Increase in other agricultural consumptive use assumed to be same as sub-basin population increase (177%).
4. Increase in recreational consumptive use assumed to be 50% (Hydroconsult 1999).
5. Increase in industrial consumptive water use is assumed to be equal to the increase in sub-basin population.

Table 7 Little Bow River Basin projected additional consumptive water use to 2021.

Little Bow River Sub-basins (including Mosquito Cr.)		Mean Monthly Demand (dam^3) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Upper Little Bow Sub-basin														
Irrigation[1]	**Mainstem**				**12.7**	**179.3**	**356.1**	**476.9**	**204.7**	**34.3**	**8.9**	**0.0**	**0.0**	**1273.0**
	Tributaries													
Stock[2]	Tributaries + GW	10.6	10.9	11.1	11.3	10.4	8.7	8.7	8.7	8.7	8.7	10.9	10.4	119.0
	Mainstem F'lots	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**	**50.0**
Other Agric (GW)														
Recreation														
Municipal	**Mainstem**					**41.8**	**53.4**	**27.8**	**27.8**	**27.8**	**53.4**	**0.0**	**0.0**	**232.0**
RF to Frank L.[3]		-187.1	-187.1	-187.1	-208.5	-187.1	-187.1	-187.1	-187.1	-187.1	-204.6	-187.1	-187.1	-2284.0
	Rural Domestic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial[4]	Other (GW)	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**12.0**
RF to Frank L.		-66.7	-66.7	-71.5	-76.3	-90.5	-95.3	-100.1	-95.3	-90.5	-76.3	-66.7	-57.2	-953.1
Totals	**Mainstem**	**5.2**	**5.2**	**5.2**	**17.9**	**226.2**	**414.6**	**509.9**	**237.8**	**67.3**	**67.4**	**5.2**	**5.2**	**1567.0**
	Tributaries + GW	10.6	10.9	11.1	11.3	10.4	8.7	8.7	8.7	8.7	8.7	10.9	10.4	119.0
	RF to Frank L.[1]	-253.8	-253.8	-258.6	-284.8	-277.6	-282.4	-287.2	-282.4	-277.6	-280.9	-253.8	-244.3	-3237.1
Lower Little Bow Sub-basin														
Irrigation	**Mainstem**				**8.3**	**89.2**	**275.1**	**373.6**	**157.3**	**12.0**	**5.5**	**0.0**	**0.0**	**921.0**
	Tributaries													
Stock	Tributaries + GW	14.5	15.0	34.9	35.4	13.4	8.3	8.3	8.3	8.3	8.3	15.0	14.0	183.6
	Mainstem F'lots	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**28.6**	**343.7**
Other Agric														
Recreation[5]				**63.6**	**63.6**									**127.3**
Municipal	**Towns, villages**													
	Rural Domestic													
Industrial	**Major Industry[6]**	**7.2**	**7.2**	**7.5**	**7.8**	**8.7**	**9.0**	**9.3**	**9.0**	**8.7**	**7.8**	**7.2**	**6.6**	**96.1**
Totals	**Mainstem**	**35.8**	**35.8**	**99.8**	**108.3**	**126.6**	**312.8**	**411.5**	**195.0**	**49.3**	**42.0**	**35.8**	**35.2**	**1488.1**
	Tributaries + GW	14.5	15.0	34.9	35.4	13.4	8.3	8.3	8.3	8.3	8.3	15.0	14.0	183.6
Mosquito Creek Upstream of Women's Coulee														
Irrigation														
Stock[7]	Tributaries + GW	3.8	3.9	25.9	26.0	3.5	2.2	2.2	2.2	2.2	2.2	3.9	3.6	81.8
Other Agric														
Recreation														
Municipal	Rural Domestic[8]	0.1	0.1	0.1	0.1	0.1	2.2	2.2	2.2	0.3	0.1	0.1	0.1	7.9
Industrial														
Totals		3.9	4.0	26.0	26.1	3.7	4.5	4.5	4.5	2.6	2.3	4.0	3.7	89.7
Women's Coulee														
Irrigation	**Mainstem**				**14.8**	**135.2**	**277.3**	**366.2**	**156.9**	**34.5**	**2.0**			**987.0**
Stock														
Other Agric														
Recreation														
Municipal	**Mainstem**					**10.8**	**9.5**	**6.8**	**6.8**	**9.5**	**10.8**			**54.0**
Industrial														
Totals	**Mainstem**	**0.0**	**0.0**	**0.0**	**14.8**	**146.0**	**286.8**	**372.9**	**163.7**	**44.0**	**12.8**	**0.0**	**0.0**	**1041.0**
Mosquito Creek Downstream of Women's Coulee														
Irrigation	**Mainstem**				**25.2**	**230.3**	**472.4**	**623.7**	**267.3**	**58.8**	**3.4**			**1681.0**
Stock	**Mainstem F'lots**	**23.0**	**23.0**	**57.1**	**57.1**	**23.0**	**23.0**	**23.0**	**23.0**	**23.0**	**23.0**	**23.0**	**23.0**	**343.9**
Other Agric														
Recreation	**Golf**				**1.0**	**8.8**	**18.1**	**23.9**	**10.2**	**2.3**	**0.1**			**64.4**
Municipal[9]	**Mainstem**	**-4.8**	**-4.8**	**-4.8**	**-28.1**	**5.5**	**37.4**	**14.9**	**19.1**	**32.8**	**48.8**	**-10.0**	**-10.0**	**95.8**
	Tributary (spring)													
	GW													
Industrial						**2.8**	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**			**16.5**
Totals	**Mainstem**	**16.4**	**16.4**	**50.5**	**76.7**	**278.5**	**540.0**	**679.4**	**309.3**	**100.5**	**53.0**	**16.4**	**16.4**	**2201.6**
	Tributaries + GW													
Basin Total	**Mainstem**	**57.4**	**57.4**	**155.5**	**217.7**	**777.4**	**1554.2**	**1973.7**	**905.8**	**261.2**	**175.2**	**57.4**	**56.7**	**6297.7**
	Tributaries + GW	29.0	29.9	72.0	72.9	27.5	21.4	21.4	21.4	19.5	19.3	29.9	28.1	392.3
	RF to Frank L.	-253.8	-253.8	-258.6	-284.8	-277.6	-282.4	-287.2	-282.4	-277.6	-280.9	-253.8	-244.3	-3237.1

Notes: 1. Increase in irrigation consumptive use based upon licence applications and crop and system mixes similar to existing irrigation.
2. Domestic herd assumed to be watered from wells and tributaries. All feedlots assumed to be sourced from mainstem.
3. Return flow to Frank Lake is from the Town of High River, Cargill Foods and the M. D. of Foothills, all of which obtain their water from the Highwood River.
4. Increase in industrial consumptive water use is assumed to be equal to the increase in basin population.
5. Increase in recreational consumptive use assumed to be 50% (Hydroconsult 1999).
6. One major industry similar in size to Cargill Foods assumed, sourced from Little Bow River Reservoir and return flows to Little Bow River.
7. Increase in feedlot stock water consumptive use for the entire Mosquito Creek sub-basin is included in the value noted for Clear Lake.
8. Rural domestic water use for the entire Mosquito Creek Sub-basin is included in the value noted for Upstream of Women's Coulee.
9. The Town of Nanton obtains its water from a spring, a well and Mosquito Creek. Its entire return flow is released to Mosquito Creek.

Table 8. Summary of estimated peak monthly (July) and annual mainstem water uses.

2001

Purpose	Highwood River Mainstem[1]				Upper L. Bow R. Mainstem				Women's Co/Mosquito Mainstem[2]				Lower L. Bow Mainstem			
	July		Annual		July		Annual		July		Annual		July		Annual	
	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%
Irrigation	1129.9	62.2%	3265.8	32.5%	739.8	94.2%	1974.7	84.0%	994.2	93.2%	2679.6	90.8%	6201.9	99.4%	15290.9	98.3%
Stock	27.8	1.5%	333.9	3.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other Agric	0.0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Recreation	48.6	2.7%	470.5	4.7%	0	0.0%	0	0.0%	47.8	4.5%	128.8	4.4%	0	0.0%	0	0.0%
Municipal	307.3	16.9%	2899.8	28.8%	45.2	5.8%	375.8	16.0%	-0.3	0.0%	-4.5	-0.2%	34.8	0.6%	262	1.7%
Industrial	301.8	16.6%	3085.7	30.7%	0	0.0%	0	0.0%	24.5	2.3%	146.8	5.0%	0	0.0%	0	0.0%
Totals	1815.5	100.0%	10055.6	100.0%	785.0	100.0%	2350.5	100.0%	1066.2	100.0%	2950.7	100.0%	6236.7	100.0%	15552.9	100.0%
(m^3/s)	0.678		0.319		0.293		0.075		0.398		0.094		2.329		0.493	
Non-irrig only	685.5		6789.9		45.2		375.8		72.0		271.1		34.8		262.0	
(m^3/s)	0.256		0.215		0.017		0.012		0.027		0.009		0.013		0.008	

[1] Includes all Highwood River mainstem uses upstream of the confluence with the Sheep River.

[2] Does not include any Mosquito Creek uses upstream of the confluence with Women's Coulee.

Additional demands to 2021

Purpose	Highwood River Mainstem[1]				Upper L. Bow R. Mainstem				Women's Co/Mosquito Mainstem[2]				Lower L. Bow Mainstem			
	July		Annual		July		Annual		July		Annual		July		Annual	
	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%	dam^3	%
Irrigation	280	30.8%	810	11.6%	477	93.5%	1273	81.2%	990	93.3%	2668	82.3%	374	90.8%	921	61.9%
Stock	12	1.3%	148	2.1%	4.2	0.8%	50	3.2%	23	2.2%	344	10.6%	29	7.0%	344	23.1%
Other Agric		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%
Recreation	24	2.7%	235	3.4%		0.0%		0.0%	24	2.3%	64	2.0%		0.0%	127	8.6%
Municipal	446	48.9%	4244	60.9%	28	5.5%	232	14.8%	22	2.0%	150	4.6%		0.0%		0.0%
Industrial	149	16.3%	1529	22.0%	1	0.2%	12	0.8%	3	0.3%	17	0.5%	9	2.3%	96	6.5%
Totals	911	100.0%	6966	100.0%	510	100.0%	1567	100.0%	1061	100.0%	3243	100.0%	412	100.0%	1488	100.0%
Non-irrig only	631.0		6155.7		33.0		294.0		71.2		574.6		38.0		567.1	
(m^3/s)	0.236		0.195		0.012		0.009		0.027		0.018		0.014		0.018	

[1] Includes all Highwood River mainstem uses upstream of the confluence with the Sheep River.

[2] Does not include any Mosquito Creek uses upstream of the confluence with Women's Coulee.

Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Historical Review of Moratoria and Diversion Rules for the Highwood/Little Bow System

Issues:

- When were moratoria imposed and lifted in the Highwood/Little Bow system? What purposes were excluded from the moratoria?
- What is the history of Highwood River Diversion Guidelines over the past 25 years?

Discussion:

- **Introduction**

Diversions from the Highwood River to support irrigation and other uses in the Little Bow River Basin have a history dating back to the early 1900s. There have been numerous changes in the locations and capacities of diversion works over the years. During the period from the late 1970s to 2002, the Women's Coulee diversion works have had a capacity of 60 cfs and the Little Bow Diversion works have had a capacity of 100 cfs. In 2003, the capacity of the Little Bow Diversion works was increased to 300 cfs. There have been several changes in water management in the Highwood/Little Bow system since the late 1970s, and there are more changes on the horizon. This Fact Sheet is intended to document the most important changes in water management to help set a context for future changes.

- **Moratoria**

When allocations on a particular stream have reached a point where it is judged that new allocations would face deficits that are sufficiently large and frequent as to render the project infeasible, water right administrators have declared moratoria on the processing of new applications. The rationale for moratoria is that there is no benefit to processing licence applications if it is unlikely that the applicant will receive water often enough to capture the intended objectives. Once a moratorium has been imposed, licence applications are held in abeyance. Applications received after the moratorium has been imposed are accepted, recorded and acknowledged, but are not processed further unless the moratorium is lifted (Controller of Water Resources 1997).

- Moratorium Imposed in the Little Bow Basin October 15, 1977.

  Rapid increase in irrigation development in the Little Bow Basin combined with low flows on the Highwood River led to the imposition of a moratorium on irrigation licensing on October 15, 1977 for the Little Bow River, Mosquito Creek and Women's Coulee. The moratorium did not apply to domestic and municipal water use.

- Moratorium Lifted July 1, 1981.

  Following further studies, the moratorium was lifted on July 1, 1981 (Alberta Environment 1985). The Little Bow Basin was open for licensing irrigation projects subject to time restrictions. Licences included cutoff dates of either July 31 or July 25, at which time irrigation withdrawals were to be suspended.

- Moratorium Re-imposed in the Little Bow Basin November 25, 1983.

Irrigation development increased dramatically between 1981 and 1983. Highwood River flow was again very low in 1983. The moratorium in the Little Bow River Basin was re-imposed on November 25, 1983. As before, the moratorium did not apply to domestic and municipal water use. The moratorium remains in place as of December 2004.

- Moratorium Imposed in the Highwood River Basin August 15, 1985.

A moratorium in the Highwood River Basin was imposed on August 15, 1985. The moratorium applied to all purposes except domestic, stockwatering, municipal and other purposes. (Under the Water Resources Act "other purposes" were purposes other than domestic, municipal, irrigation and other agricultural, industrial and water power. Other purposes would include recreation and water conservation projects). In 1990, the moratorium was modified to no longer exempt "other" purposes. This moratorium remains in place as of December 2004.

- Frank Lake Project

The Frank Lake Wetland Project represents a milestone in management of the Highwood/Little Bow system. It removed a significant source of nutrients from the Highwood River, reducing the growth of aquatic vegetation and decreasing the related sag in dissolved oxygen.

In 1987, Cargill Foods Ltd. proposed constructing a large meat packing plant in the High River area. A key associated issue was the management of wastewater from the plant. Discussions among Cargill, the M.D. of Foothills, the Town of High River, Ducks Unlimited Canada and the Departments of Environment and Transportation and Utilities led to the identification of Frank Lake as a potential receiving body for treated wastewater effluent from both Cargill and the Town of High River. Critical issues were addressed, landowners around the lake were briefed, funding was arranged, and on May 11, 1988 the Frank Lake Wetlands Project was announced at a press conference in High River (Alberta Environment 1997a).

A pipeline from the Town of High River to Frank Lake, licensed to the M.D. of Foothills, has been constructed to divert up to 3014 acre feet of treated wastewater from the Town and Cargill Foods. Ducks Unlimited Canada also has been licensed to divert up to 2000 acre feet from the Highwood River to Frank Lake through the works of the M.D. The latter licence prohibits diversions during July and August when Highwood River water quality problems are most likely to occur.

Construction was completed in May 1989 and in July treated wastewater was pumped to Frank Lake. Combined effluent from Cargill Foods and the Town of High River is pumped to Frank Lake continuously. Ducks Unlimited Canada diverted water from the Highwood River to Frank Lake during initial filling in 1991, 1992 and 1993 (Golder Associates 1997). While the Frank Lake Wetland Project has improved water quality in the Highwood River, there are water quality issues within Frank Lake and in spill water that enters Little Bow River upstream of the new Little Bow River Reservoir. Issues are being addressed.

- Highwood River Diversion Guidelines

The guidelines for operating the Women's Coulee and Little Bow diversion works, both owned and operated by Alberta Environment, have changed over the past 25 years. Following is a summary of the key changes. Details regarding the locations of monitoring stations and operating protocols have not been included in the summary.

- Pre-1985 Guidelines

In the late 1970s and early 1980s, water was diverted from the Highwood River to the Little Bow River basis according to an informal guideline (often referred to as the 10/30 Guideline) allowing diversion of up to 10%

of the natural flow at Women's Coulee Diversion and up to 30% of the natural flow at the Little Bow Diversion. The total capacity of the diversion works was 160 cfs. In 1984, Highwood River flows were very low and irrigation demands high due to hot, dry weather during the growing season. The peak demands could not be met under the 10/30 guideline. Lower priority users were shut down. Following representations from Little Bow water users, a Ministerial Order was issued allowing diversion of up to 50% of the natural flow for period July 23 to August 15, 1984. A temporary gravel weir was constructed in the Highwood River downstream of the Little Bow Diversion works in mid-July to enable additional water to be diverted (Alberta Environment 1985; Alberta Environment 1997b).

- 1985 Highwood River Diversion Guidelines

Complaints from Highwood River riparian landowners about low summer flows and reported fish kills prompted Alberta Environment to impose more restrictive diversion guidelines on their structures.

Divert up to 160 cfs as required to meet demands in the Little Bow Basin, subject to:
a) a minimum Highwood River flow of 70 cfs, and
b) diversion of not more than 60% of the Highwood River natural flow.

Water users in the Little Bow Basin accepted the guidelines as an interim measure pending completion of the ongoing planning studies and development of storage to alleviate water supply deficits.

- 1986 Highwood River Diversion Guidelines

In 1986, temperature criteria were added to the guidelines, making them more restrictive.

Operate as in 1985 and conditions a) and b), subject to an additional condition:

c) If the Highwood natural flow is less than 360 cfs during the period July 6 to August 10, and air temperature reaches 30^{0}C or water temperature reaches 22.5^{0}C, then:

Highwood Natural Flow H_{NAT}	Maximum Total Diversion D_{MAX}	Minimum Highwood Flow H_{MIN}
$280 < H_{NAT} < 360$*	$D_{MAX} = H_{NAT} - 200$	$H_{MIN} = 200$
$160 < H_{NAT} < 280$	$D_{MAX} = 80$	$H_{MIN} = H_{NAT} - 80$
$H_{NAT} < 160$	$D_{MAX} = 0.5\ H_{NAT}$	$H_{MIN} = 0.5\ H_{NAT}$

* This condition can be read, "When the Highwood natural flow is between 280 and 360 cfs, then $D_{MAX} = H_{NAT} - 200$ cfs and $H_{MIN} = 200$ cfs."

Again, the Little Bow water users went along with the changes only as a temporary constraint until measures could be implemented to alleviate water deficits.

- 1990 Highwood River Diversion Guidelines

In 1990, significant changes to the guidelines were made when the Highwood River is under temperature or dissolved oxygen stress conditions.

Operate as in 1985 and conditions a) and b), with two added conditions:

c) If water temperature exceeds 24^{0}C or dissolved oxygen is less than 5.0 mg/L or the Highwood River natural flow is less than 150 cfs, then diversions for irrigation purposes will be temporarily suspended. Diversions for other purposes will not exceed 20 cfs.
d) To protect canal bank stability, reductions in diversions may be initiated when water temperature exceeds 22.5^{0}C or dissolved oxygen is less than 5.5 mg/L.

- 1991 Highwood River Diversion Guidelines

The 1991 guidelines were almost the same as the 1990 guidelines, except:

- The 150 cfs criterion was deleted from condition c).
- The provision for immediately resuming irrigation diversions when temperatures fall below 24^0C and dissolved oxygen rises above 5.0 mg/L was added to condition c).
- A provision for freshening flows to improve water quality along the Little Bow River and Mosquito Creek was added.

- 1992 Highwood River Diversion Guidelines

The 1992 guidelines changed the provision for resumption of irrigation diversions that were temporarily suspended due to temperature or oxygen conditions. The 1992 guideline specified that,

Resumption of diversions for licensed irrigation will be contingent on evaluation of overnight water temperature and oxygen data and predictions of air temperatures for the current operating day.

- 1994 Highwood River Diversion Guidelines

The 1994 guidelines are referenced in the proposed Highwood River Interim Diversion Plan to guide diversions to meet pre-Little Bow Project licensed water uses. The 1994 guidelines have not changed significantly from 1992, however they are summarized in full because of their significance to the proposed interim operating plan (Alberta Environment 1994). For exact wording, official documents should be sought from Alberta Environment.

During the period May 1 to September 30, divert up to a total of 160 cfs at the Women's Coulee and Little Bow Diversions as required to meet domestic and licensed municipal, irrigation and industrial uses in the Little Bow Basin, subject to:

a) Irrigation diversions will not cause the flow in the Highwood River fall below 70 cfs.
b) When the Highwood River natural flow is between 90 and 270 cfs, not more than 60% of the Highwood River natural flow will be diverted.
c) When the Highwood River natural flow is between 40 and 90 cfs, the diverted flow will be 20 cfs.
d) When the Highwood River natural flow is less than 40 cfs, the diverted flow will be limited to 50% of the natural flow.
e) If the water temperature in the Highwood River exceeds 24^0C, or dissolved oxygen is less than 5.0 mg/L, diversions for irrigation will be temporarily suspended. The minimum diversions for domestic, municipal and industrial uses will be 20 cfs. Additional flow may be diverted to protect water quality for domestic and municipal purposes. Resumption of diversions for licensed irrigation will be contingent on evaluation of overnight water temperature and oxygen data and predictions of air temperatures for the current operating day.
f) To protect diversion canals from rapid drawdown that would cause unstable canal banks, diversion rates may be reduced when the Highwood River water temperature exceeds 22.5 ^{0}C or dissolved oxygen falls below 5.5 mg/L. Irrigators will be notified regarding the possibility of such cutbacks.

An extension may be granted to irrigators who have licences with cut-off dates if there is a demonstrated need for the water and if water is available in the Little Bow River, Mosquito Creek or Women's Coulee.

When water is available in the Highwood River, diversions will be increased as necessary to provide a freshening flow to improve water quality in the Little Bow Riverand Mosquito Creek for domestic and municipal use. The total diversion will be up to 160 cfs in the spring and up to 50 cfs in the summer and fall.

Subject to water availability, structural capability and a demonstrated need for the water, consideration will be given to extending the normal summer operating period for the Women's Coulee and Little Bow Diversions into April and October.

During the period October 1 to April 30, 20 cfs or 50% of the natural flow, whichever is less, will be diverted at the Little Bow Diversion. There will be no diversion at Women's Coulee.

There were no significant changes in the diversion guidelines between 1994 and 2002.

Summary of Key Findings

Pre-Little Bow Project diversion guidelines changed considerably over the years since the last moratorium on irrigation licences was imposed in November 1983. The pre-1985 10/30 Guideline was replaced by a complex set of rules that included temperature and oxygen criteria. Comparing the original 10/30 Guideline with the most recent (1994) guideline, allowable diversions are more limited when the Highwood River natural flow is less than 120 cfs, or temperature and oxygen conditions apply under the 1994 guidelines. When Highwood River natural flow exceeds 120 cfs and temperature and dissolved oxygen conditions do not apply, the 1994 guidelines permit higher diversions.

References:

Alberta Environment 1985. Little Bow River Basin Study Phase I Summary Report: Inventory. Planning Division, Calgary, AB.

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Alberta Environment 1997a. Joint Review Panel Hearing, Little Bow Project/Highwood Diversion Plan: Submission of Alberta Environmental Protection. Alberta Environment. Lethbridge, AB.

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Fact Sheet

Highwood Water Management Plan -- Phase I: Highwood Diversion Plan

Topic: Highwood River Aquatic Protection and Diversion Rules

Issues:

- What are the relationships between Instream Needs, Instream Objectives and Water Conservation Objectives?
- What Instream Need values did the Instream Flow Needs Technical Working Group recommend?
- What are the diversion rules that were used in simulation modelling of the Highwood/Little Bow system? How do these diversion rules relate to the Instream Needs recommended by the Technical IFN Committee?
- What is the relationship between diversion rules used in modelling and Instream Objectives or Water Conservation Objectives for the Highwood River?

Discussion:

- **Introduction**

There are a number of terms that are often used interchangeably to describe flows required for the protection of the aquatic environment and instream uses. The terms may have different meanings to different people. This Fact Sheet is intended to define such terms in a manner that is consistent with the *Water Act* and the ongoing water management planning for the South Saskatchewan River Basin (AENV 2002). This Fact Sheet will also describe the Instream Needs recommended for the Highwood River by the Instream Flow Needs Technical Working Group, the diversion rules used for simulation modelling, and the relationship between the two.

- **Definition of Terms**

Instream Needs (IN) are the scientifically determined flow rates or water quality conditions required to sustain a healthy aquatic environment and to meet human instream needs such as recreation, navigation, wastewater assimilation and aesthetics. The term IN is often referred to as Instream Flow Needs (IFN), which has the same meaning. Key considerations in determining IN are defining critical stream reaches, defining critical instream aquatic values and uses that require protection, and adopting or developing methods for defining instream requirements for selected uses. Often one or two of the most sensitive uses are selected as surrogates for all instream use requirements. Withdrawal uses of water are not considered in determining IN.

Instream Objectives (IO) are the desired levels of flow or water quality that have been established considering the needs for protection of the aquatic environment, instream uses, and existing and future withdrawal uses of the stream. Establishing IO involves water management planning where compromises and trade-offs are considered and decisions are sometimes made by consensus based on unquantified value judgments. Simulation modelling helps to provide an understanding of the inter-relationships among variables and the trade-offs involved. Knowledge of IN for the stream provides a perspective on the extent to which instream values are being compromised by trade-offs.

Instream Objectives can be implemented by AENV by including IO as constraining conditions on withdrawal licences, and through operations of provincially-owned water management works, such as the Oldman River Dam or Dickson Dam. IO can also be a factor in issuing effluent discharge approvals under the Alberta Environmental Protection and Enhancement Act.

Water Conservation Objectives (WCO) are the amounts and quality of water established by the Director (the Director is designated under the *Water Act* by the AENV Minister) to be necessary for the protection of a natural water body or its aquatic environment, or any part thereof, and for protection of tourism, recreational, transportation or waste assimilation uses of water, or management of fish or wildlife. In establishing the WCO, the Director must engage in whatever level of public consultations that the Director feels is appropriate.

Water management planners may recommend to the Director that IO be established as WCO. WCO can be implemented as conditions on withdrawal licences or effluent discharge permits, through the operation of provincial water management works, or by issuing a licence (upon application by government) for unallocated water necessary to remain in the stream for the purpose of achieving an established WCO. Water could be made available for contributing to a WCO from licence transfers to the government, cancelled licences or a 10 percent holdback on licence transfers between willing sellers and willing buyers.

Diversion Operational Rules refer to a set of rules or guidelines established to guide operators of water management works to control flows and water levels in a manner that is consistent with legal requirements, policy direction and the objectives of the project. On some projects, guidelines may be extensive and complex. They will incorporate the legal priorities and requirements of other projects using the same source of supply. The operational rules may also incorporate IO or WCO for the protection of instream uses and the aquatic environment.

For the purposes of simulation modelling for the Highwood/Little Bow/Mosquito Creek system, operational rules were considered to be variables to be tested by scenario iterations. For each scenario, operational rules were formulated and input to the model to instruct the model on how to manage flows at diversion points and storage reservoirs. Model outputs were analyzed to evaluate performance in meeting objectives. Modelled operational rules that provide acceptable performance may form the basis for IO or WCO, depending on public input and recommendations of the PAC.

- **Recommended IN for the Highwood River**

The Instream Flow Needs Technical Working Group was established in September 1998 to review past instream flow needs studies for the Highwood River, and to provide a science-based instream flow determination for the river (Clipperton et al. 2002). Several approaches for determining instream flow needs were considered, recognizing that there is no one method that has gained acceptance or favor over others. The "natural flow paradigm" was used as a guiding principle (sidebar).

The **"natural flow paradigm"** is becoming widely accepted among aquatic scientists and natural resource agencies around the world. Aquatic ecosystems have adapted to long-term variability in flow magnitude, frequency, duration, timing, and rate of change. Maintaining a similar pattern of flow variability is critical to the long-term sustainability and biodiversity of the aquatic and associated eco-systems.

The final recommendation of the Technical Working Group was based upon a time series analysis of scenarios that were defined as various percentage reductions from weekly natural flows. Habitat indices (Weighted Usable Areas) were computed for each scenario and all life stages for mountain whitefish and rainbow trout for the river reach between Aldersyde and the Sheep River confluence (Segment 4). Bull trout juvenile and adult life stages were also considered for the river reach between Women's Coulee and High River (Segment 2). Evaluation metrics were established as percentage reductions from natural Weighted Usable Areas that the working group judged would still provide a high level of protection and be acceptable, considering the magnitude of uncertainties inherent in the habitat computations. The three key metrics that were used for comparisons among scenarios and, their respective threshold reductions from natural habitat that were deemed acceptable were:

		Acceptable Reduction Threshold
•	Loss in average habitat.	Less than 10 percent reduction from natural.
•	Maximum weekly loss in average habitat.	Less than 15 percent reduction from natural.
•	Maximum one-week loss in habitat.	Less than 25 percent reduction from natural.

From evaluation of the scenarios using the three key metrics, the Working Group concluded that, subject to base flow constraints, the following instream flow requirements would provide a high level of protection of the aquatic ecosystem:

- Segment 2 – at least 80 percent of the natural flow.
- Segment 4 – at least 85 percent of the natural flow.

The Working Group recognized that low natural flow periods in the Highwood River create limiting habitat conditions. A reduction in flow during these periods could result in substantial negative impacts to the aquatic ecosystem. To provide additional protection during low natural flow periods, the Working Group established a threshold flow below which the instream flow requirement was 100 percent of the natural flow. This threshold value was referred to as the Ecosystem Base Flow. The Ecosystem Base Flow was established as the larger of:

- the flow corresponding to the 80 percent habitat exceedence value for the life stage with the highest flow requirement (mountain whitefish adult) for each week, or
- the weekly 95 percent flow exceedence discharge.

The Working Group decided to provide further protection for the late season weeks by extending the mid-August Ecosystem Base Flow, determined as above, through the remaining weeks of the open water season as a constant.

- **Diversion Operational Rules for Simulation Modeling**

Diversion operational guidelines considered in the modelling included:

- Pre-project 1994 Highwood Operating Guidelines (all scenarios)
- Alberta Transportation's 80% Fish Rule Curve proposed in the 1995 EIA (Scenario IDP2.1.1 only).
- Technical Working Group recommended Highwood IFN, or some variation of it (all scenarios except BC2.2). The variations considered are discussed in the following section.
- Separate drought operational guidelines triggered by low runoff forecasts and low reservoir storage levels (Scenarios IDP2.5.2.9.8C and IDP2.5.2.9.9).

More information on operational guidelines and priorities is provided in the document, "Scenario Construction and Priorities" (AENV 2003A). Information on the drought operational guidelines and how they were incorporated in scenarios is provided in the Fact Sheet, "Drought Period Operation Procedures" (Hart 2003). Instream Objectives for the Highwood River and guidelines for diversions to the Little Bow River and Mosquito Creek were treated as management variables in the scenarios. The Technical Working Group's recommended Highwood IN were modified in systematic iterations primarily in attempts to strike a balance between fish habitat on the Highwood River and irrigation performance on the Clear Lake and Lower Little Bow expansion blocks.

- **Variations of the Recommended IN That Were Considered in Modelling**

Numerous iterations involving variations of the recommended IN were formulated and tested. It is important to note that for modelling purposes it was assumed that pre-project licences would have priority over the new IO (when established) for the Highwood River. These licences would be subject to the same operational guidelines and priorities that existed in 2001, prior to development of the Little Bow Project. In modelling, it has been assumed that the new IO would have priority over diversions from the Highwood River to the Clear Lake and Little Bow River Reservoirs.

The variations in the recommended IN that were considered as potential IO in the six scenarios under review are as follows. The performance of each of the scenarios is summarized in separate Scenario Performance documents.

- Scenario BC2.2 – Base Case.

Scenario BC2.2 represents pre-project conditions circa 2001. It represents a time period that pre-dates development of the recommended IN. The IN is therefore not considered in the scenario.

- Scenario IDP2.1.1 – Interim Operating Plan.

The full recommended IN (red line in Figure 1) was used as the IO for the period July 15 to August 31. The 80 percent Fish Rule Curve, as proposed by Alberta Transportation in their EIA reports on the project, was used for periods April 1 to July 14 and September 1 to October 31. Scenario IDP2.1.1 is the proposed interim operating plan that will be in effect until a new Highwood River IO and diversion guidelines have been established.

- Scenario IDP2.3.2 – Fish Habitat Priority.

IO Rule #1 was used for the entire operating season April 1 to October 31 (red and green lines in Figure 1). IO Rule #1 provided fishery habitat performance that was judged to be equivalent to the full IN recommended by the IFN Technical Working Group.

- Scenario IDP2.5.2.9 – Improved Irrigation Performance.

IO Rule #3 was used for the entire operating season April 1 to October 31 (red and blue lines in Figure 1). The adjustment from Rule 1 to Rule 3 was made to reduce irrigation deficits while minimizing the impact on Highwood fish habitat. The minimum operating flow target for the Upper Little Bow was also increased from 20 cfs to 30 cfs.

- Scenario IDP2.5.2.9.8C – Drought Period Operation Rules.

IO Rule #3 was used for normal operations during the entire operating season April 1 to October 31 (red and blue lines in Figure 1 – same as Scenario IDP2.5.2.9). A drought operation rule that was used only in multi-year droughts was implemented to avoid back-to-back deficits greater than 100 mm.

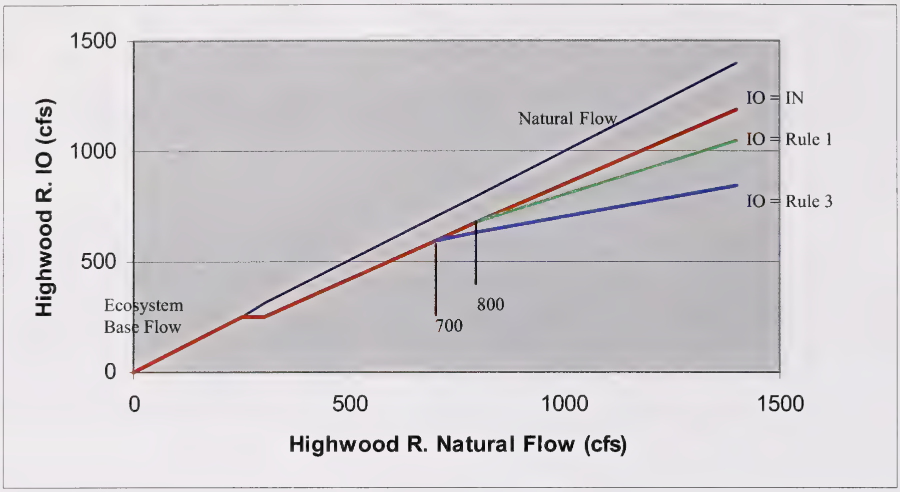
- Scenario IDP2.5.2.9.9 -- Increased Non-irrigation Water Use.

Scenario IDP2.5.2.9.9 used the same rules as for Scenario IDP2.5.2.9.8C. The purpose of this scenario was to test the impact on irrigation deficits and fish habitat of increases in non-irrigation water use.

- **Relationship Between Scenario Operating Rules and an IO or WCO**

It is proposed that the six scenarios be reviewed and discussed by the Public Advisory Committee and the general public. If there is a consensus that the performance of a particular scenario is balanced and provides adequate performance, and the scenario is recommended as a basis for the Highwood Diversion Plan, the **assumed IO** in the scenario operation rules may be recommended as the IO for the Highwood River, or an interim IO if it felt that more information is needed or other options should be considered. The Director may choose to formally establish the IO, or some variation of it, as a WCO or interim WCO to provide a higher level of protection and more options and flexibility for implementation. Water could be secured through licence transfers to government or water conservation holdbacks to eventually achieve the WCO over a period of time.

Figure 1 Variations of the recommended IN considered in simulation modelling.



Notes: 1. The Ecosystem Base Flows vary weekly. For instance, for the week April 23 to April 29, they are all flows up to 207 cfs; for the week July 16 to July 22, they are all flows up to 352 cfs.

2. For Scenario IDP2.3.2 the Rule Curve deviates from the red line at Qnat = 800 cfs and follows the green line (IO Rule #1). At Qnat = 1400 cfs, the IO for Rule #1 = 0.75 Qnat or 1050 cfs.

3. For Scenarios IDP2.5.2.3, IDP2.5.2.9, IDP2.5.2.9.8C and IDP2.5.2.9.9 the Rule Curve deviates from the red line at Qnat = 700 cfs and follows the green line (IO Rule #3). At Qnat = 1400 cfs, the IO for Rule #3 = 0.60 Qnat or 840 cfs.

4. The difference between the natural flow line and the particular IO line that is under consideration in the scenario represents the flow available for consumptive use along the Highwood River and for diversion to the Little Bow Basin through the Women's Coulee and Little Bow Diversions.

References:

AENV 2003. South Saskatchewan River Basin Water Management Plan Phase II: Background Studies. Environmental Management, Southern Region, AENV. Calgary, AB.

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HIGHWOOD DIVERSION PLAN CONSULTATION

Highwood Management Plan Public Advisory Committee

REPORT ON PUBLIC CONSULTATION EFFORTS AND RESULTS
OCTOBER TO DECEMBER 2004

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About this Report

Bill McMillan of Equus Consulting Group Inc. was contracted by Alberta Environment to independently summarize and assess the public consultation process and results for the Highwood Diversion Plan.

Prior to the public consultation, Bill provided advice to the Highwood Management Plan Public Advisory Committee (PAC) about requirements and expectations. After the PAC had conducted its consultation process, Equus analyzed the results and all documentation of the consultation.

The following report provides an independent summary and expert opinion about the consultation process and results.

1.0 Summary

1.1 Summary results

The Highwood Management Plan Public Advisory Committee (PAC) held five public “open house” meetings in October and December 2004. The purpose of the open houses was to allow any interested party to provide input or response to a set of proposed recommendations to guide diversion and storage of water in the Highwood/Little Bow river basins.

The eighty-one (81) participants who completed a response form at one of the open house meetings support the efforts and recommendations of the PAC, as evidenced by the following results:

- 94% support the objectives of the PAC (none were opposed),
- 92% are satisfied the PAC is making appropriate recommendations (one person disagreed),
- 83% indicated the information they received was clear or very clear,
- 87% indicated they received the right amount of information at the open house meetings,
- 92% indicated that PAC members were helpful and open-minded at the meetings.

In addition, the PAC asked about public preference regarding the future allocation of water in the Highwood river basin. There was a range of opinion about this topic, but a majority of respondents preferred either closure of the basin, or limitations on future allocation:

- 33% preferred closure of the basin,
- 31% preferred limiting future allocation to non-irrigation purposes (this proposal may have been misinterpreted by some participants),
- 19% preferred to continue to allocate water for any purpose,
- 17% did not express an opinion.

1.2 Conclusions

The responses received at the open house sessions indicate a high level of approval for both the work of the PAC and the recommendations they have created. The participants in the consultation process indicated they want to see the recommendations implemented with as few delays as

possible. There was high satisfaction with the efforts of the PAC to provide useful and clear information to those who attended. However, some considerations were raised at the sessions that should be addressed by the PAC (and Alberta Environment):

- There is some frustration that the process has taken a long time.
- The implementation of the recommendations must be monitored and reported, possibly by a multi-stakeholder committee. Some participants suggested the PAC should take on this role. Some noted the need for clear public information during implementation.
- Several participants would like to see additional recommendations to address erosion and pollution concerns in the watershed.
- Some participants were concerned that applications-in-progress may require special consideration, since expectations have changed during the several years of analysis and discussion.
- A few participants felt the rationale for rejecting water storage as part of future water management was either not clear or not convincing.
- The question on future allocation priorities produced ambiguous results so the PAC should provide a clear rationale for its recommendation in this area. Some PAC members felt there may have been some confusion about what was implied by the three options presented.

2.0 Consultation Methods

2.1 Notification and advertising

The PAC provided direct notification, by mail, to all stakeholders who had registered previously in public discussions of the "Little Bow Project/Highwood Diversion Plan." Local First Nation representatives were also notified by mail. However, no First Nation representatives attended the open houses.

In addition, public notices were placed in weekly newspapers on both September 29 and October 6, in Okotoks, High River, Nanton, Vulcan and Claresholm. Information was also available prior to the open house meetings at the municipal offices in the same communities noted above, and including the M.D. No. 31.

The PAC members themselves represented a broad range of interest groups and each member made a personal effort to ensure their constituencies were informed of the consultations.

Reviewer's comments: The effort to inform potentially interested parties was reasonable. There is no evidence that parties with an interest felt they missed their opportunity to have input. However, some participants indicated they would have liked to receive more information prior to the open houses. Ideally, there would be follow up with the Eden Valley band to ensure they are aware of the recommendations.

2.2 Open house sessions

Five open house sessions meetings were held, all using the same meeting format. At each open house, PAC members were present to provide information about the study area, options and recommendations. PAC members were supported by water management experts from Alberta Environment. A total of five stations each provided specific information to participants:

1. **Registration/departure area**: provided an information package and received response forms.
2. **Orientation area:** provided information about PAC, the study area, and reason for the study,.
3. **Modeling analysis and scenario options area:** described how options were identified and selected.
4. **Recommendations area:** described preferred scenario and recommendations.

5. **Conference table area:** encouraged participants to discuss options and recommendations.

Over 100 people attended the open house sessions. Of those, eighty-one (81) completed response forms describing their opinions. The process was not designed to test public opinion in a statistical manner, but rather to provide an open opportunity for input and advice, and to gauge public perceptions of the proposed recommendations.

Reviewer's comments: The process was well organized, and participants commented that information was accessible and understandable. All identified user sectors were represented at the open houses with the exception of industrial users. Participants in the open house sessions represented a reasonable geographic cross-section of the affected area. Attendance numbers and patterns were within the predictable range for this kind of process. Nothing about the behaviour of participants or the pattern of attendance indicates a potential unstated concern, or an organized opposition to the recommendations. No correspondence was received during the consultation period that would indicate opposition to the recommendations.

3.0 Compilation of Responses

For these results, "N" represents the number of persons who responded. Percentages may not equal 100% due to rounding.

3.1 Number of respondents

A total of 81 completed response forms were collected at the following five open house events:

Vulcan Legion in Vulcan, Alberta
October 4, 2004 from 4:00 to 9:00 pm
October 5, 2004 from 7:30 to 10:00 am

Highwood Memorial Centre in High River, Alberta
October 6, from 4:00 to 9:00 pm
October 7, from 7:30 to 10:00 am

Champion Community Centre in Champion, Alberta
December 8, from 4:00 to 7:30 pm

3.2 Respondent categories

Participants were asked to indicate their primary use of water, their area of residence, and their interests in order to test whether or not the open houses attracted a cross-section of stakeholders. Of the 73 people who indicated their gender, 19 (26%) were women and 54 (74%) were men.

Respondents indicated their primary use of water as follows:

PRIMARY USE OF WATER	N	%
Irrigation	22	29%
Non-irrigation agriculture	23	30%
Municipal use	17	22%
Industrial use	0	0
Recreation	7	9%
Other	8	10%
TOTALS	**77**	**100%**

Respondents described their place of residence (in order of times chosen) as follows:

Resident	Times Chosen
Within study area	46
Near the Little Bow River	26
Near the Highwood River	23
Within a town or village	19
Near Mosquito Creek	14

Respondents indicated their interests in the Highwood Diversion Plan (in order of times chosen) as follows:

Interests	Times Chosen
Reliability of water supply for consumers	69
Environmental requirements (e.g. instream flow needs; wetlands maintenance)	66
Maintaining aesthetic quality of river	63
Community or social concerns	36
Public costs	31
Private costs	22

3.3 Response to questions about the PAC report

3.3.1 Do you agree with the objectives of the Public Advisory Committee?

Yes	No	No Opinion
73	-	5
94%	-	6%

N = 78

<u>*Comments from those who indicated their agreement*</u>:

- I agree in most part, although too much importance is put on the minimum flow of the Highwood. In reality, the flow would be a lot less had weirs not been put on the Little Bow to divert water down the Highwood.
- Should speed the project up so we could get things rolling.
- It would appear the Committee has chosen membership from all stakeholders and covered all concerns adequately.
- Water is the life of this area and cannot be wasted. Public advice is paramount.
- Doing good. Hope for work as fast as you can.

- I am concerned with the increased water demand from all sources.
- Good job. One or our biggest concerns is water quality coming from Frank Lake into the Little Bow going into Twin Valley. We have seen too much phosphorous (foam) spilled at the H.R. Colony outlet into the Little. Is any improvement being done at H. River?
- The Highwood PAC Committee did a fantastic job.
- Doing great job, but sure take their time.
- I believe PAC has appropriately devised a balance between meeting demands while maintaining the river and aquatic ecosystems.
- Excellent framework for success.
- PAC has done an excellent job in researching, interpreting and sharing the information. Their recommendations are thoughtful and considered and I trust their opinions.
- Public input necessary.
- Totally agree and appreciate the concern and dedication of the PAC. It has taken years and hundreds of hours of input to achieve what is presented here tonight. The input was from a broad spectrum of concerned people at all levels of involvement and we value the results.
- Speed up the project.
- I would like to see an increase in the minimum flow. Right now we have a lot of weed growth and mud bars. I understand this is one of the PAC recommendations and I agree.
- Objectives appear feasible. The most important factor will be ongoing monitoring and assessments to allow adjustments in accord with conditions.
- After twenty some years of consultation, it will be nice to put this to rest. To satisfy all parties is quite a feat.
- I feel confident the proposed scenario is the most intelligent and practical. I feel it will protect the integrity of the streams and the studies will form a basis for Phase II. If all the work put into this was done before major projects i.e. Clear Lake, Cargill, Twin - it may have saved a lot of money. As it is, I feel PAC is not recommending an expanded Women's Coulee saved taxpayers a lot of money.
- I believe the objectives of the PAC will result in a fair way of distributing the dwindling supply of surface water in the Highwood River Basin. It is a compromise solution which considers everyone in the Highwood River Basin as a result of the limited supply of water available in the Basin. It treats all residents of the Basin equally and fairly.
- Water management should be a top priority.
- I also believe it should be an objective to maintain water quality of ULB and MC (as well as the Highwood).
- I believe the process has taken a very long but obviously necessary time to come to these conclusions. The objectives are sound and "user friendly."

- I have some concern regarding removal of July cutoffs unless the policing (enforcement) is very well done.
- The public should know what is going on. Also many have information of the past that is not in a book or document. 2. After public consultation of all areas a consensus should be arrived at - giving a fair and possible solution to future water problems and allotments.
- Impressed with the modeling that has been done. Would like to see continued emphasis on conservation. Glad to see no further usage of Women's Coulee Reservoir. Excellent attempt has been made to represent all stakeholders. Also impressed with the consideration of social impact.

Comments from those who indicated "no opinion" or who did not indicate any response:

- For the most part but more input from people who live on the river should be looked at.
- I am concerned about meeting the water needs of High River in the future. We may eventually need water from the Highwood for our use. It seems the people downstream benefit greatly from the water flowing through High River.

3.3.2 Are you satisfied the PAC is making appropriate recommendations?

YES	NO	NO OPINION
69	1	5
92%	1%	7%

N = 75

Comments from those who indicated their satisfaction:

- Yes, doing well.
- I would like to see a recommendation that because of the uncertainty created by the unreasonable time required for the PAC to make recommendations and have them approved, irrigators who because of the Twin Valley Reservoir became unable to use their historically used water licence rights, be given an additional period of three years after the final recommendations are approved to re-allocate their licence (by temporary or permanent transfer or by modified use on original point of diversion land).
- Once again, more emphasis on conservation and water quality (i.e. Cargill/Frank Lake/Little Bow) - habitat. What about water quality upstream on the Highwood (i.e. feed lots!)?
- More concern of best use of water rather than aesthetic concerns. Is economic value of IFN for aesthetic value ever measured? Less concern for fish on small reach - more concern on large picture of total river health.

- It's obvious the PAC has worked well in balancing the needs of a variety of stakeholders.
- Adequate funds for monitoring and information sharing.
- The monitoring for adaptive management needs to be recognized and supported by government.
- I am very impressed with the PAC's recommendations. Especially the concept of without future storage. I also feel the component of monitoring and adaptive management is essential to understanding the system.
- This is an exciting sequence of information and outcomes. The process seems effective and I applaud all 8 recommendations! I especially consider 1.2 value and hope the Phase II studies will further enable effective management.
- Our expectation is that the monitoring is done otherwise the whole process of managing is for naught.
- Fair distribution.
- We are very opposed to the Women's Coulee expansion for a long list of important reasons and value to results presented. The irrigation issues certainly need re-evaluation. We are concerned re the number of sports fishery companies in existence. We are concerned with the rapid town growth and their future water needs - water and growth cap? You have been very thorough.
- I believe there are a lot of issues that haven't been dealt with that I'm extremely unhappy about: e.g. water wells, (monitoring) erosion control, erosion stopped cattle from getting to creek, no access or increased cost of access, construction damages, etc.
- I think it is very important that a core group be set up for monitoring this Diversion Plan and that people from the current PAC be on that group. A lot of thought and information has been obtained that was not available when this process started in 1997. I think a lot of the missing information has been collected (except for fisheries) to make a well informed decision. I thank all the people who took time out of their busy lives to look after the interests of the Highwood River and surrounding area. Well done! Recommendation #8 - agree the process should not stop here - need to continue the studies on the IFN and proceed with Phase II of the WMP.
- The PAC did not directly address maintenance and protection of the watershed. Many factors (grazing management, limits on clear cut logging, control of OHV use could be implemented to ensure continued, reliable release of water from upper watershed through the streams). The monitoring and management will be a very large, ongoing effort throughout the Bow-Oldman basin.
- Why don't they clean the silt and drift soil out of the bottom of the dam that is there?
- Wondering about Phase 2 - what is to be expected in the future?

- I expect the recommendations will make the water director's job easier. I am concerned that it will be difficult to have the monitoring budget to carry on with what needs to be done. This is very important to future decisions on this basin and all other basins.
- I am especially pleased with conservation vision to be pursued in Phase II.
- I would like to see the recommendations acted upon by the Minister(s) of government department(s) involved and not shelved (and acted on in a timely manner). There should be continuing consultation by the Minister(s) with the executive of PAC so that the recommendations are fully followed and as intended. These recommendations should be a basis on which Phase II will start from, so coordination is necessary between Phases I and II.
- I am very impressed with what PAC has done. Regarding HMP, Phase 2, is storage an option that will be considered? Also, with all the work that has been done, and given the joint panel will consist of new members, I am concerned about how the new board will view these recommendations.
- It appears they have worked hard and done their homework. It is important that proper follow up is done.
- Long-term monitoring must be done. Results must be presented within a reasonable time frame. Hydrological information must be obtained so that linkage between river and municipal wells can be determined. Solutions to problems identified should be science-based rather than the "easy-one" based on opinion, or supposition.
- Since it has been decided at this time that Women's Coulee will not be expanded or have storage increased, don't you think its time it was maintained and dredged? The silt levels are deplorable and accumulation is in feet and the weed problems along the banks are ridiculous. It would also recommend fencing along the shores and implementing solar cattle watering stations to stop the tremendous amount of erosion taking place.
- Regular and ongoing monitoring of the diversion to ensure objectives continue to be met and no negative impacts have materialized. Plans in place to revise water management plan (with public input) as required due to population growth/decline, environmental study findings, etc.
- It appears PAC is very sensitive to all needs.
- I agree with all the recommendations presented and feel they are very logical from both an aesthetic and financial sense.
- Upper Little Bow landowners were led to support the Little Bow project by selling it as a project that would benefit all stakeholders. Upper Little Bow landowners were led to believe (promised, in fact) that increased irrigation would be possible. It is apparent from these studies water is not available for fulfilling this promise. It would be significant for this PAC to make some recommendations as to how those landowners are to be compensated for this "misinformation" that was fed to the landowners of the Upper Little Bow. Or is this beyond the mandate of the Highwood PAC. I feel that it was an expectation of the NRCB that this shortfall would be met in a sense of fairness!!!

- My concern after viewing the PAC recommendations is the sour gas well SW of town. This impact on our water system is not mentioned.

Comments from those who indicated "no opinion" or did not indicate any response:

- 1. Treat the Little Bow and the Highwood River equally on all aspects. 2. Stop all flow from Frank Lake. 3. Improve river water quality in both rivers. Please keep in mind the weirs in place on Highwood River re the amount of water flows to be adequate in the Little Bow River.
- In most part from what I saw today, the recommendations are positive. My hope is in reality they are able to do what was proposed.
- Water and river quality most important.
- I would like to see High River's future water needs considered as important as downstream users.
- Enforcement and monitoring especially in the irrigation sectors are a concern to me. As Canadians, we seldom are punitive enough and we seem to have a society developing that will risk overuse unless the repercussions are suitable to the crime.

3.3.3 Which of the following approaches do you prefer?

Allocation	N	%	Notes
Close the basin to future allocation	27	33%	This preference least supported by those who live in a town or village
Limit future allocation to non-irrigation purposes	25	31%	This preference least supported by those who live near Mosquito Creek
Continue to allocate water for any purpose	15	19%	This preference least supported by those who live near Highwood River
No Response	14	17%	3
Totals	**81**	**100%**	

Comments from those who wish to close the basin to future allocation:

- Protect all existing licence holders.
- It's irresponsible to continue allocation of unsustainable water supplies.
- Future development is going to occur. The approach of limiting water from the Highwood is imperative.
- Based on the data collected from studies done during Phase I, it appears the water has all been allocated (if not over-allocated). As a result, the basin should be closed to future allocation unless efficiencies are made in the use of the present volumes of water available. In the near future, it appears that the water available from the mountain areas

will start to dwindle and the residents of the Highwood River Basin depend on this source of water.

- We cannot continue to have future growth without knowing how to deal with the future water demands. It seems to me that reduced water use and water conservation by everyone is needed now and perhaps government should consider putting this into law.
- By allowing more future allocations you run the risk of water shortage. When there is a shortage it would be very difficult to police the use and a very good chance that high priority licences down stream not receiving their allocated amount.
- If the recommendation is that the basin cannot supply further expansion this recommendation should be implemented.
- I am concerned that the impacts of continued development along the Highwood will limit the water diverted to Little Bow and Women's Coulee especially during summer months due nutrient loading. Developments like golf courses, country resident, gravel pits.) Because domestic use is a priority, water flow in the Little Bow and Mosquito, agriculture could be restricted by some urban developments. When are Environment and the M.D. going to become concerned?
- If monitoring is properly done the model can be adjusted in the future and perhaps there will be opportunities. If we continue to over-allocate, the pressure on our elected officials and government workers will force a collapse of the basin ecosystem.
- Close until further storage above on the Highwood is found.
- This is a no-brainer.
- I am vehemently opposed to any consideration of storage in Women's Coulee for municipal use. I believe this option needs to be taken out of the future allocations. All the affected landowners need to be made aware of the decision ASAP. If storage is not going to happen the storage capacity of the dam should be maximized by cleaning up the facility i.e. dredging, fencing livestock away, etc.
- Risk consideration paramount.
- If there is not enough water then there is not enough water!! All areas concerned are going to have to accept the consequences. There has to be a careful plan for all future water.
- ...until HWMP - Phase II is completed. Really need IFN studies done in order to establish what's available for future needs.
- It is my opinion that allocations have been made to the limit (or perhaps beyond) the supply of water.

Comments from those who wish to limit future allocation to non-irrigation purposes:

- Water in the future will become a very valuable resource. The population will grow and their needs must be looked after. Perhaps the agricultural allocation is satisfactory for now. *(also checked approach #1)*
- ...and commercial.
- I feel that the Province should limit irrigation uses within the basin and help the municipalities to secure water for future residential uses. Human consumption prior to irrigation!
- Make sure the river and water quality is not hurt. Any future allocation should be done slowly over many years to make sure it will work. Should be better communication between government divisions involved and between government and the people this dam affected.
- Carefully monitor applicants' use.
- Implementation of education to help us all be more thoughtful, practical and efficient in our water use would benefit everyone.
- Municipal growth in High River and Okotoks will place greater demands on both the Highwood and Sheep Rivers. Unless some other source is found (e.g. pipeline from Calgary), there will be pressure to increase licences to accommodate growth. Industrial demands can be limited by the available supply and both provincial and municipal policy.

Comments from those who wish to continue to allocate water for any purpose:

- We all own the water and pay for this project - everyone should be able to share in the benefits.
- But meter usage and charge rate to assist in dissuading waste and ensuring maximum availability in drought conditions!!
- ...except in the following case, or to enhance the following cases: Provided allocation is within recommended guidelines already set out. Projects of development which include irrigation for tree farms that enhance our environment should be encouraged. Fresh water should not be licensed to oil and gas companies to flush down their holes.
- New licences should be aware there may be shortfalls and be prepared to live with the consequences.
- I would expect that demand will increase as traditional dryland crops continue to decline in value and specialty crops increase in value.
- But proceed with caution for a couple of years!?
- ... any "essential" purpose - Every application for allocation must be carefully investigated.
- Make them aware of supply shortfalls when they are allocated.

- Build and construct more storage, a dam/reservoir on the Little Bow River between the Town of High River and the (Little Bow Dam) Twin Valley Dam/Reservoir.

Comments from those who did not indicate a preference:

- Reasonable habitat reduction should be allowed on Highwood (i.e. 10% total not 2-4%). Allow licences to this point.
- This is a hard question to answer because of increasing population and drier weather conditions.
- Closing the basin is necessary but if there are any past issues lingering with individuals outstanding, these have to be resolved within a set time frame.
- Water issues in the Highwood will continue to be important. I believe a forum representing key stakeholders needs to be maintained to ensure informed decisions are made on the above three points. I can envision scenarios whereby all three approaches could apply.
- Allocate water for best use, most responsible use rather than a first come, first serve basis.
- There needs to be further investigation of the fishing in Highwood to determine this IFN demand. Other options for bring water conservation and for augmenting supply. Municipal planning needs to look more closely at water supply in planning growth.
- Limit water for farm crop use only.
- Wait until the post-project situation is better understood. Environmental flows are essential and 'sharing the shortage' may be considered (similar to the southern trib's of the Oldman).
- Limit future allocation to irrigation uses to provide assurances of adequate water supply to the Town of High River.
- I feel the government should retain all future water rather than issue licences for irrigation. This water is committed forever and will be bought and sold for huge dollars. This water may be required for far more important reasons. This water could be tendered or licensed for short term e.g. 1-5-10 years. As other requirements arise, the government would have these short-term licences expiring. To license more and more water will create buying and selling of water at huge dollars and the governments gets nothing.

3.4 Consultation evaluation

Participates evaluated the consultation by responding to the following questions.

3.4.1

On a five-point scale ranging from Very Unclear to Very Clear, how will you rate the clarity of the information you were given as part of this consultation?

Note: the scale was weighted from 1 (Very Unclear) to 5 (Very Clear). **The mean (average) rating was 4.14.**

VERY UNCLEAR				VERY CLEAR
1	2	3	4	5
3	3	7	32	33
4%	4%	9%	41%	42%

N = 78

3.4.2

On a five point scale ranging from Too Little to Too Much, how will you rate the amount of information you were given as part of this consultation?

Note: the scale was weighted from 1 (Too Little) to 5 (Too Much). **The mean rating was 3.12.**

TOO LITTLE		RIGHT AMOUNT		TOO MUCH
1	2	3	4	5
-	1	68	8	1
-	1%	87%	10%	1%

N = 78

If "too little," what additional information will you like to see?

- It would be interesting to see the complete supply demand picture with supply quantified for a given year. Also, the above illustrated to show statistical supply as compared to forecasted demand.
- It would have been nice to have had a little time to go through some of this before I got here to ask questions.
- If additional information is needed by anyone, they should be directed to the bibliography which should be made available to the public-at-large. This information should be located at a library which has a central location in the Highwood Basin.
- I would have preferred to have had an opportunity to review the information presented prior to this meeting. I feel like I am being rushed into filling out these forms NOW!

- More info regarding alternatives that were being considered in addition to the recommended course (and include M.D. maps to better showcase area under consideration).
- I would be interested to see a breakdown of who/what uses the water so we know what controls are best for now and in the future.
- I am, however, somewhat familiar with the system.
- My concentration is very old but it was very well presented and such good people have done so much work.

3.4.3

On a five point scale ranging from Strongly Disagree to Strongly Agree, were the PAC members and their advisors helpful and open-minded?

Note: the scale was weighted from 1 (Strongly Disagree) to 5 (Strongly Agree). The mean rating was 4.53.

Strongly Disagree		Fence		Strongly Agree
1	2	3	4	5
2	0	4	20	50
3%	0%	5%	26%	66%

N = 76

Unit Conversion Factors

SI Units (metric)	Imperial Units
Area	
1.0 hectare (ha)	= 2.471 acres
1.0 square kilometres (km^2)	= 0.386 square miles
Length	
1.0 millimetre (mm)	= 0.039 inches
1.0 metre (m)	= 3.281 feet
1.0 kilometre (km)	= 0.621 miles
Volume	
1.0 litre (l) = 0.001 cubic metre	= 0.0353 cubic feet
1.0 cubic metre (m^3) = 1000 cubic litres	= 35.315 cubic feet
1.0 cubic decametre (dam^3) = 1000 cubic metres	= 0.811 acre feet